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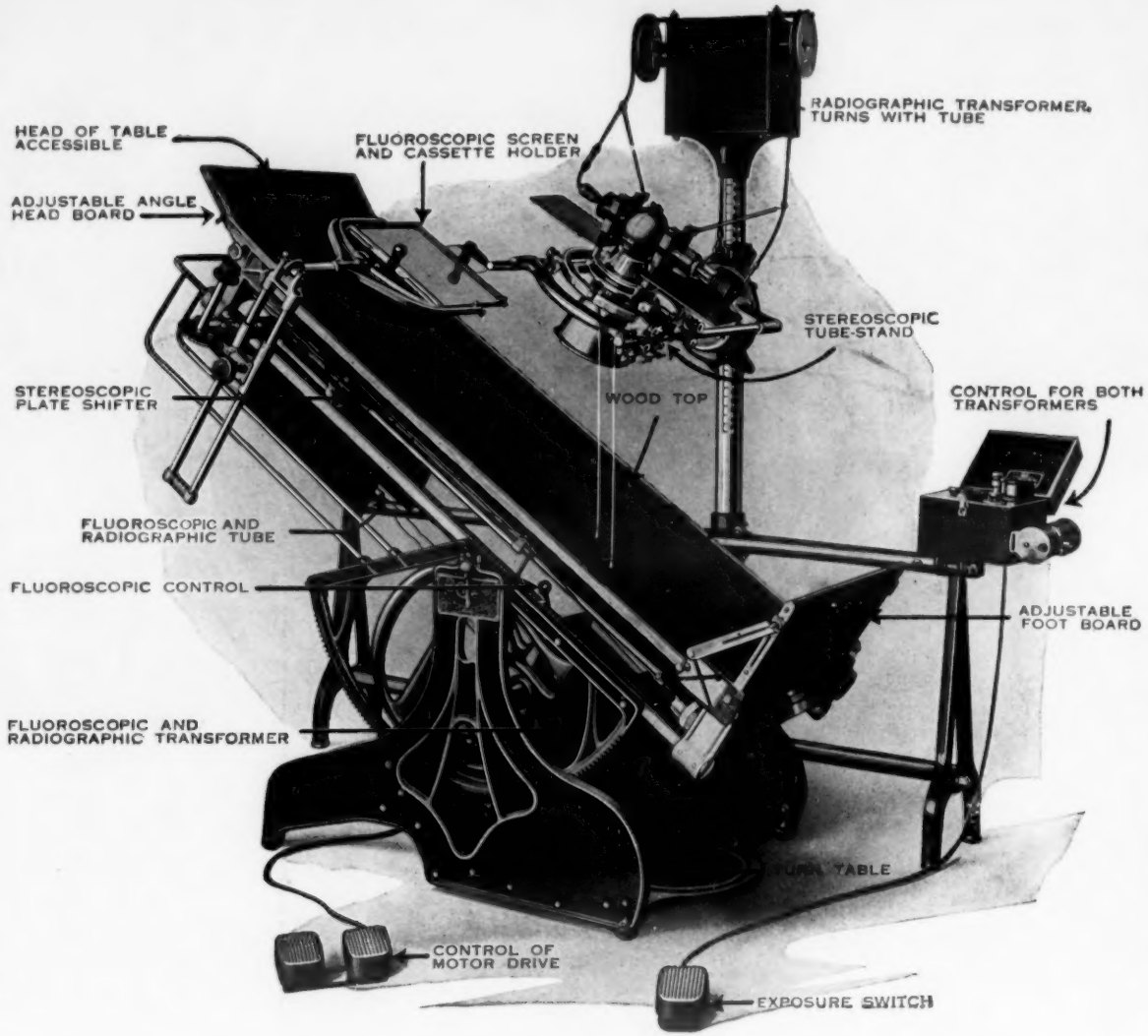


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THE AMERICAN JOURNAL OF ROENTGENOLOGY

VOL. IX [NEW SERIES] JULY, 1922 No. 7

# THE PRODUCTION OF PENETRATING X-RAYS*

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## I. INTRODUCTION

IN the treatment of certain types of malignant disease by radiation, better results can be obtained by using the penetrating $\gamma$-rays from radio-active substances than by employing $x$-rays. The chief difference between the two methods of treatment lies in the fact that the $\gamma$-rays are more penetrating than the $x$-rays, and that the $\gamma$-rays therefore project larger amounts of radiant energy into the deeper lying tissues as compared with the energy absorbed in the skin than the $x$-rays do. Although it will take a long time definitely to decide how much can be actually accomplished, the recent reports from Central Europe indicate that massive $x$-ray therapy has certain advantages; and this has greatly stimulated interest in penetrating roentgen radiation.

Several years ago, the writer began certain researches designed to determine just what to do in order to produce $x$-rays of great penetrating power. At its meeting in 1914, he presented to the American Roentgen Ray Society a brief statement of some of the preliminary results. The present paper contains a description of more recent experiments, and a statement of the conclusions to be drawn from them.†

Since the researches by Laue and the Braggs,[1] scientists have come to the conclusion that the $x$-rays consist of a series of waves travelling through space. We call the distance from one wave to the next preceding wave, or to the next following wave, a wave-length, and we usually denote this distance by the Greek letter $\lambda$. If this distance is the same for all the waves, the radiation is said to be homogeneous.

It has been found by experiments that a great many properties of $x$-rays depend upon their wave-lengths. For instance, the penetration of the $x$-rays through matter generally, *but not always*, increases as the wave-length of the $x$-rays decreases. Let us take as a definition of the penetration of an $x$-ray the distance, D, it travels through matter before half of the radiation has been absorbed or scattered. Except in certain cases described below, this distance D, is related to the wave-length approximately as represented by the following equation:

$$D = \frac{.693}{a\lambda^3 + b}, \qquad (1)$$

where a and b are constants depending upon the nature of the substances traversed by the rays. If equation 1 represents the facts, in order to *increase* the penetration (i.e. *increase* D) we must *decrease* the wave-length $\lambda$.

The object of the researches described in this paper has been (a) to determine the best means to employ in order to produce $x$-rays of very short wave-lengths; (b) to compare their intensity and penetration with those of the $\gamma$-rays from radio-active substances.

* A Leonard Prize Paper.
† In carrying out these researches I have had the assistance of a number of students.

## II. METHOD OF MEASURING WAVE-LENGTHS

In measuring the wave-lengths of the *x*-rays I have used Bragg *x*-ray spectrometers.[1] The arrangement of the apparatus for measuring long, easily absorbed *x*-rays differs slightly from that used in measuring short, penetrating *x*-rays. Figure 1 represents the instruments employed in the first case. The *x*-ray tube was made in our laboratory and was exhausted by means of a set of pumps attached to the tube marked A. The pumping system consisted of a rotary oil pump, a Gaede rotary mercury pump, and a mercury diffusion pump, all three in series with each other.

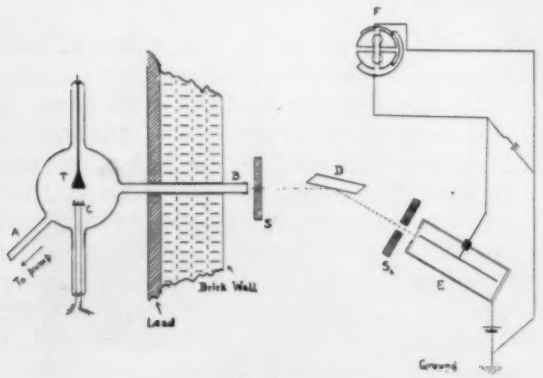


FIG. 1.

A glass trap immersed in liquid air between the diffusion pump and the tube A served to condense out the mercury vapor. A Coolidge cathode, (C in the Figure) supplied the electrons which passed across and struck the target T. The *x*-rays there produced passed through the side tube and out through a thin mica window at B. The use of this long side tube and mica window markedly reduced the absorption of the roentgen radiation by the air, and by the walls of the *x*-ray tube. The target and window were so placed that the *x*-rays actually analyzed—on leaving the target almost grazed its surface. This gives a very narrow source of rays as seen from the window B. The side tube passed through a hole in a brick wall, which separated the room containing the *x*-ray tube from that in which the *x*-rays were examined and analyzed. The brick wall furnished excellent protection to the operator and to the measuring instruments against the effects both of the stray *x*-rays and of the electrical disturbances produced by the high potential currents through the *x*-ray tube. This protection becomes of very great importance when very high potentials are used, and in these cases a large sheet of lead 1 cm. thick was attached to the wall on the side toward the *x*-ray tube as an additional shield.

After emerging from the window B, the *x*-rays passed through a narrow slit, $S_1$, in a block of lead 1 cm. thick. They then impinged upon the surface of a crystal of calcite, D, supported on the table of a spectrometer, by means of which the

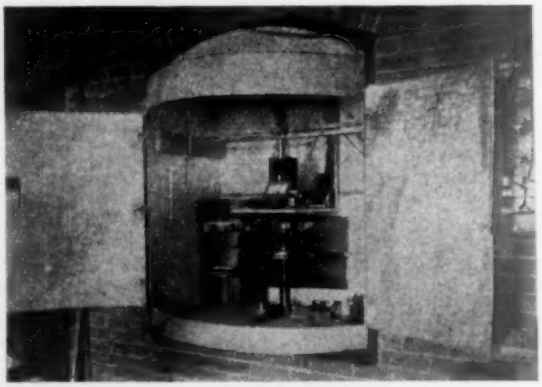

PLATE 1.

glancing angle, $\theta$, could be accurately measured. Under these conditions the crystal reflects some of the *x*-rays. It markedly reflects those only of the *x*-rays that have the wave-length given by the equation

$$\lambda = 2d \sin \theta \qquad (2)$$

For calcite, $2d = 6.056$, if the wave-lengths are expressed in terms of the usual unit, the ångström. One ångström equals $10^{-8}$ cm. The part of the *x*-ray beam reflected from the crystal subsequently passed through a second slit, $S_2$, and then entered an ionization chamber, E. A quadrant electrometer, F, measured the electrical current through this ionization chamber. Although the ionization current is not strictly proportional to the intensity of the roentgen radiation, it may be taken to represent approximately the amount of energy absorbed by the gas in it. The gases sulphur dioxide, ethylbromide, and methyliodide were used in different experiments.

In analyzing very penetrating *x*-rays the

long side tube and mica window B make very little difference, and an ordinary Coolidge tube can be used in place of the one above described. Plate I shows a reproduction from a photograph of the spectrometer.

### III. THE GENERATING PLANT

Two sources of high potential current have been used in the researches. In measurements of extreme accuracy a high potential storage battery supplied the current through the *x*-ray tube. The battery consisted of 20,000 small storage cells, furnishing, when fully charged, an electromotive force of over 40,000 volts. Only by using sections of the battery could any difference of potential below this value be obtained. Such a battery furnishes a non-fluctuating voltage. Its electromotive force, however, gradually decreases when it begins to run down, and in order to maintain the given difference of potential between the electrodes of the *x*-ray tube, the following well-known device was employed. The positive pole of the battery was joined directly to the anode of the *x*-ray tube (Fig. 3). The negative pole of the battery was connected through a variable resistance to the ground (water pipes). The small electrical circuit that heats the Coolidge cathode was joined to the same ground connection (water pipes). Under these conditions, when a current passes through the tube, a change in the variable water resistance will alter the potential of the *x*-ray tube's target, for some of the electromotive force of the battery is utilized in forcing the current through the water resistance. By observing the potential of the target as described below, and by suitably varying the water resistance, the difference of potential across the tube can be kept exceedingly constant during an experiment.

In experiments with voltages higher than 40,000 volts I have used an arrangement of apparatus first employed years ago in Europe for charging electrical condensers to very high, constant differences of potential by means of induction coils or transformers. Figure 2 represents the circuits. An alternating current (in my experiments usually 500 cycles per second) passes through the primary circuit, P, of the transformer, T. One end of the secondary coil of the transformer is connected to the ground. Under these circumstances the potential of the other terminal, S, of the secondary coil oscillates between plus and minus V volts, V being the maximum voltage delivered by the transformer. A, in Figure 2, represents an electrical valve which allows positive electricity to flow in the direction of the arrow, but not in the reverse direction. When the potential of S is positive, the current flows through this valve to the plate C of the electrical condenser, charging it up

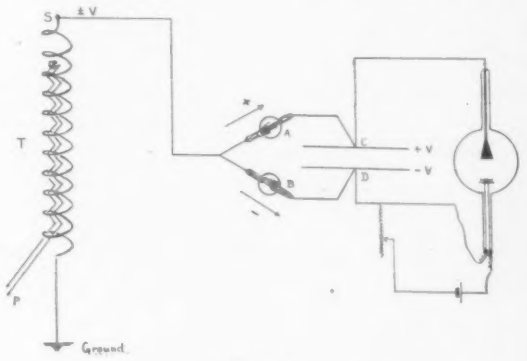


FIG. 2.

to the maximum positive potential plus V volts. The positive electricity cannot flow back through the valve A, and therefore the plate C retains its positive charge. When the potential of the terminal, S, is negative, negative electricity can flow through the valve B (which points in a direction opposite to A), and this negative electricity charges the plate D of the condenser to a negative potential minus V volts. The negative electricity cannot pass back through the valve, B, again, and therefore the plate, D, retains its negative charge. In this way we get a total difference of potential between the condenser plates, C and D, of 2 V volts, i.e., twice the maximum voltage supplied by the transformer. The target and cathode of the *x*-ray tube are joined to the two condenser plates, as represented in Figure 2. Under these conditions, if too large a current does not pass through the *x*-ray tube, the difference of potential across it remains approximately constant.

In the early experiments with this arrangement of apparatus, partially exhausted discharge tubes were used as valves. Dr. A. W. Hull, however, has designed very much better valves, utilizing the electrons from hot tungsten wires. These valves he calls kenotrons. Ordinary Coolidge *x*-rays tubes may be used as valves, however, and for very high voltages the new large-sized Coolidge *x*-ray tubes appear to give the best results.

### IV. MEASUREMENT OF THE DIFFERENCE OF POTENTIAL

I have employed several methods of measuring the voltage applied to the *x*-ray tubes. Figure 3 represents the arrangement of the apparatus designed to measure the voltage with great accuracy. The high voltage battery, B, has its positive pole joined to the target of the *x*-ray tube as indicated. The circuit heating the

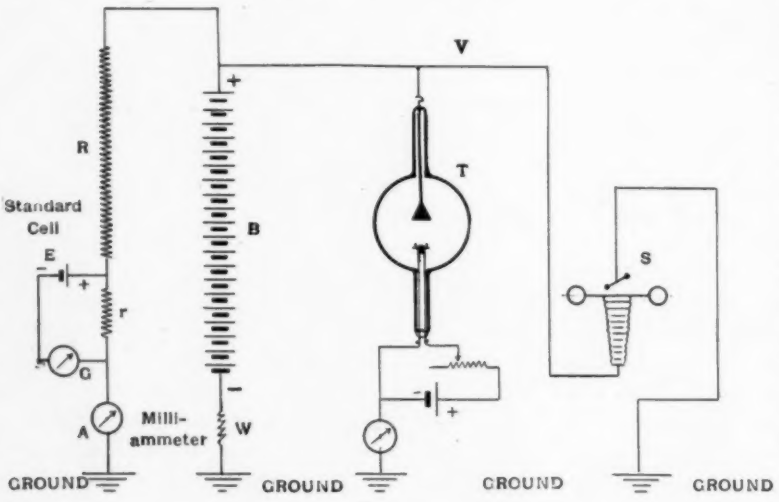


FIG. 3.

cathode of the tube is connected to the ground (water pipes). The negative pole of the battery is also connected to the ground through the variable water resistance, W. A second circuit connects the positive pole of the battery to the ground through a set of manganin wire coils of very high resistance, R, a very much smaller resistance, r, and a milliammeter, A. A side circuit connects the terminals of the small resistance, r, through a standard cell, E, and a very sensitive galvanometer, G. A current of $10^{-11}$ ampere through this galvanometer produces a deflection of one millimeter on its scale. The electromotive force of the standard cell, E, opposes the flow of current from the main circuit through the galvanometer. In the particular case in which this electromotive force exactly equals the fall of potential along the resistance, r, no current passes through the galvanometer. Under these conditions the difference of potential between the target of the *x*-ray tube and the ground—that is, the total fall of potential along the circuit, Rr, bears the same ratio to the electromotive force, E, of the standard cell that the total resistance in the circuit, R+r, bears, to r. In other words, the equation

$$V = E\,\frac{R + r}{r} \qquad (3)$$

gives the value of V in volts. In the most accurate measurements of V, I have used two standard cells, each of which had been measured by the Bureau of Standards at Washington. The Bureau certified the values of their electromotive forces, E, to within one part in ten thousand. The ratio of the resistances, R and r, I measured by the Wheatstone's Bridge Method. In this measurement standard resistance coils, the values of which had previously been determined at the Bureau of Standards, formed the arms of the bridge. The resistances of these coils were checked up several times with a considerable number of other standard coils, so that, as a result of the whole series of measurements, I have an exceedingly accurate estimate of the ratio $\frac{R + r}{r}$. As the comparison of two resistance coils can be made with extreme accuracy, it is probable that we know the above ratio much more accurately than we know the electromotive force of the standard cell. Extreme precautions were taken with the insulation of the circuits. Further,

in the measurement of the ratio of the resistances, the same current passed through the circuits as passed through them in the *x*-ray measurements, so that the temperature conditions remained similar in the two cases. It seems probable, therefore, that the voltage applied to the *x*-ray tube is known with about the accuracy with which the electromotive force of the standard cell was determined at the Bureau of Standards, namely, to within about one part in ten thousand.

This extreme accuracy can be obtained only when the high potential storage battery furnishes the current through the *x*-ray tube. The variations of the voltage produced by the generating plant, described above, considerably exceed the errors of the measurement. In experiments that do not require this extreme accuracy the voltage may be estimated by measuring the current flowing to the ground through the milliameter, A. This current, multiplied by the total resistance in the circuit (R + r), gives directly the voltage V.

Further, in experiments in which it is not desired to use more current than that passing through the *x*-ray tube, the voltage of the tube may be measured by means of the electrostatic voltmeter, S. This consists of two metal balls suspended so as to turn about a vertical axis. A metal wire connects these balls through their suspension to the ground. Another highly insulated wire connects the target of the *x*-ray tube to two large fixed balls. The electrical charges on the fixed balls attract the charges induced on the movable balls and turn them around through a certain angle. This angle is measured in the usual way by means of a mirror telescope and scale. The angle of deflection depends upon the voltage used, and, as the instrument is not an absolute instrument, it becomes necessary to determine by experiments just what voltage corresponds to each value of the angle of deflection. This can be done by measuring the voltage as described above, and by observing the corresponding readings of the electrostatic voltmeter.

As one often uses a spark gap parallel to the *x*-ray tube as a measure of the voltage applied to it, I have compared the values given by such a gap with those recorded on the calibrated electrostatic voltmeter. For high voltages I had to use the transformer generating plant described above. As slight fluctuations in the current coming from the power plant occur, this calibration does not appear to be as accurate as that for lower voltages, in which the storage battery supplied the current. The spark gap consisted of two polished metal balls 12.5 cm. in diameter. The Victor Electric Company kindly loaned it to me. In making the experiment, the voltage was gradually raised until a spark passed between the balls, and the reading of the voltmeter was observed at the instant the discharge took place. A graduated scale at the base of the supports for the two metal balls indicated the voltages for different settings of the gap. Column 1 of Table I contains these indicated voltages.

TABLE I

DIFFERENCE OF POTENTIAL IN VOLTS

| Spark Between 12.5 Cm. Balls | Electrostatic Voltmeter |
|---|---|
| 90,000 | 88,000– 90,000 |
| 100,000 | 100,000–101,000 |
| 110,000 | 109,000–111,000 |
| 120,000 | 120,000–122,000 |
| 130,000 | 128,000–131,000 |
| 140,000 | 138,000–140,000 |
| 150,000 | 148,000–149,000 |
| 160,000 | 156,000–158,000 |

A number of readings were made for each setting of the balls. The readings of the electrostatic voltmeter did not vary more than about one per cent from their mean value. The voltages as measured by the electrostatic voltmeter for the extreme readings in each case appear in column 2 of Table I. The difference of potential given by the scale on the 12.5 cm. ball spark gap agrees very well with that indicated by the calibrated electrostatic voltmeter.

### V. THE *x*-RAY SPECTRA PRODUCED BY DIFFERENT VOLTAGES

If we apply a constant voltage to an *x*-ray tube we do not get *x*-rays all of which have the same wave-length.[2] The curves in

Plates II, III, IV, etc., illustrate the wave-lengths of the *x*-rays actually obtained under given conditions. In these curves the abscissae represent the wave-lengths, or the angles as measured on the *x*-ray spectrometer, and the ordinates represent

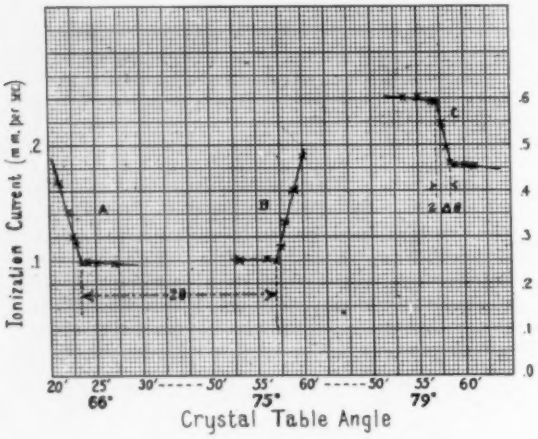


PLATE II.

the corresponding currents in the ionization chamber. All the curves have one peculiarity in common. In each case the curve shows a certain minimum wave-length, $\lambda_m$, and no *x*-rays come from the tube that are shorter than this minimum. The

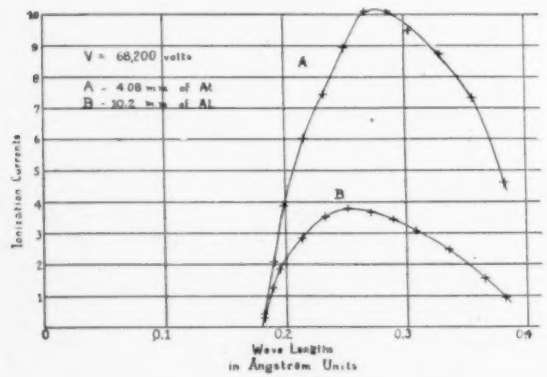


PLATE III.

relation between the minimum wave-length and the voltage applied to the tube was discovered several years ago.[2] The relation may be expressed by the equation

$$V\lambda_m = K \qquad (4)$$

where K is a universal constant. Theoretically this relation means that a certain general law (known in physics as the quantum law) applies to *x*-rays. Although of great scientific importance, it does not seem necessary at present to enter into a discussion of this question.[3]

Equation 4 shows that the value of the minimum wave-length obtained in a given case may be decreased by increasing the voltage applied to the tube, and that it varies inversely as this voltage. At the time this law was discovered, many of

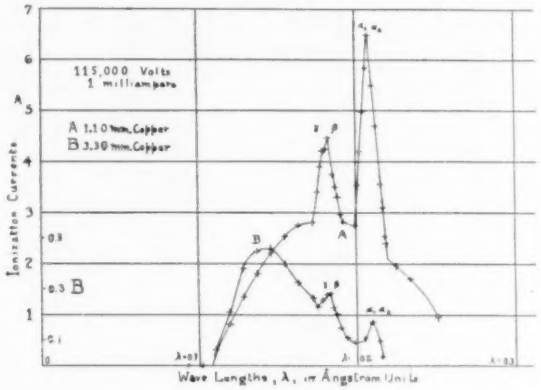


PLATE IV.

the best physicists believed that the law did not apply, and that you could not get *x*-rays shorter than a certain wave-length, no matter how much you increased the voltage. During the last few years, however, the law has been tested and found correct in a number of laboratories in this country and abroad.[3]

## VI. A REMEASUREMENT OF THE VALUE OF THE PRODUCT $V\lambda_m$

The exact value of the product $V\lambda_m$ appears to be of considerable importance in the science of *x*-rays as well as in general physics. In cooperation with Palmer and Yeh, I have measured it recently, therefore, using all possible precautions to obtain great accuracy. In these experiments the storage battery supplied the current through the *x*-ray tube and the potential of the target was measured by the standard cell method, the resistances having the values R = 6,039,500 ohms and r = 252.01 ohms. An assistant observed the galvanometer, G, in Figure 3, and regulated the variable water resistance, W, in such a way that no current passed through the galvanometer during an experiment. Under these circumstances the voltage, V, of the target remained constant during the measurement, and

equaled the value given by equation 3. A second observer regulated the current that heated the Coolidge cathode coil, so as to maintain the current through the tube constant, and at the same time measured the ionization current. The curves A and B in Plate II represent the results obtained in one series of measurements. The horizontal portions of these curves give the values of the ionization currents due to stray radiation, etc. The incline portions of the curves indicate the increases in the ionization currents due to the *x*-rays close to the short wave-length limit of the spectrum. The curve A corresponds to measurements made on one side of the zero of the spectrometer, and curve B to measurements on the other side, after turning the crystal around so as to reflect the rays in the other direction. The abscissae represent the readings on the angular scale of the spectrometer. Since readings were taken on both sides of the zero, the whole angle between the point where the *x*-ray spectrum ends on one side, to the point where it ends on the other side, equals twice the angle, $\theta$, that must be substituted in formula 2 to calculate the minimum wave-length. This value of $\theta$, however, does not represent the exact magnitude of the angle. A small correction has to be made for the fact that the spectrometer's slit and the focal spot on the target have certain finite magnitudes. This correction we estimated in two ways,—firstly, by measuring the breadths of the slit and the focal spot, and, secondly, by measuring the breadth of an absorption line in the *x*-ray spectrum, as described below. Curve C in Plate 2 gives the readings of the ionization current in a determination of the correction by the second method. The breadth of the drop in this curve corresponds to the correction, $2\Delta\theta$, that must be added to the double angle, $2\theta$, to get its true value.

The data obtained in four complete sets of measurements of $V\lambda_m$ appears in Table II.

Column 2 contains the values of $\theta$ uncorrected for the breadth of the slit and of the focal spot. Column 3 contains the correction to be added to $\theta$, and column 4 the corrected values of $\theta$. Column 5 contains the values of $V\lambda_m$, the average of which is 12,354. In each of these experiments the voltage, V, applied to the tube amounted to 24,413 volts, as measured by comparison with the electromotive force of the standard cell.

TABLE II

| Date | $\theta$ (uncorrected) | $\Delta\theta$ | $\theta$ (corrected) | $V\lambda_m$ |
|---|---|---|---|---|
| March 15 | 4° 46′ 43″ | 47″ | 4° 47′ 30″ | 12,350 |
| March 21 | 4° 46′ 53″ | 43″ | 4° 47′ 36″ | 12,353 |
| March 30 | 4° 46′ 53″ | 51″ | 4° 47′ 44″ | 12,360 |
| April 5 | 4° 46′ 48″ | 45″ | 4° 47′ 33″ | 12,352 |

In the above series of measurements the *x*-rays came from the target of the *x*-ray tube in a direction at right angles to the direction of motion of the cathode particles. In order to see whether any change in the value of $V\lambda_m$ would take place if the *x*-rays came from the tube in a different direction,[5] we made a second series of measurements with a tube so placed as to investigate the rays coming off at an angle of 45° from the direction of motion of the cathode particles. Table III contains the results obtained in this series of measurements.*

TABLE III

| Date | $\theta$ (uncorrected) | $\Delta\theta$ | $\theta$ (corrected) | $V\lambda_m$ |
|---|---|---|---|---|
| April 6 | 4° 46′ 35″ | 1′ | 4° 47′ 35″ | 12,353 |
| April 6 | 4° 46′ 33″ | 1′ | 4° 47′ 33″ | 12,352 |
| April 12 | 4° 46′ 53″ | 48″ | 4° 47′ 41″ | 12,358 |
| April 27 | 4° 46′ 43″ | 47″ | 4° 47′ 30″ | 12,350 |

As in the previous series of measurements, the voltages amounted to 24,413 volts. It appears from the data contained in the fifth column that the value of $V\lambda_m$ is the same for rays coming off at an angle of 45° as for those coming off at right angles to the cathode rays.

## VII. EFFECTS OF FILTRATION ON THE *X*-RAY SPECTRUM

Experiments have been performed to determine the change in the *x*-ray spectrum produced by interposing sheets of metal between the *x*-ray tube and the spec-

* This value agrees with that obtained by Blake and Duane, *Phys. Rev.*, Dec., 1917, p. 624. It has, however, greater accuracy than the 1917 measurement.

trometer (filtration). These effects may be divided into two classes, normal and abnormal filtration. In normal filtration the interposed plate reduces the intensity of the *x*-ray of all wave-lengths to a certain extent.[2] The reduction is much greater for the long waves than for the short, however. Hence, the *x*-ray beam, after it has passed through the filter, contains a larger proportion of short *x*-rays than before. In other words, on the average the *x*-rays have been shortened. The minimum wave-length, however, remains exactly the same. The curves in Plate III show the results of experiments on this question in the case of high filtration. The abscissae represent the wave-lengths, and the ordinates, the ionization currents. It appears that the shortening of the wave-lengths, due to an increase of filtration from 4.08 mm. to 10.2 mm. of aluminum, although perceptible, does not amount to very much. The reduction in the intensity of the roentgen radiation by the filter, however, appears very marked. The maximum ionization current due to the filtered rays amounts to only 37 per cent of that due to the unfiltered rays. In these curves the voltage, 68,200, was not large enough to produce the K series of characteristic *x*-rays.

The curves in Plate IV represent experiments at a voltage of 115,000 volts. In this case the voltage is high enough to produce the K series of *x*-rays, and they are represented by the peaks of curve A. Curve B represents the effect produced by increasing the filtration from 1.1 mm. of copper to 3.3 mm. of copper. It appears that the latter filtration almost suppresses the peaks on the curve corresponding to the K series of tungsten, and that almost all of the wave-lengths of the *x*-rays that get through the 3.3 mm. filter are shorter than those of the K series. These curves represent normal filtration.

In abnormal filtration the filter, in general, reduces the intensity of longer waves more than of shorter waves, except at a certain critical wave-length. At this wave-length there appears a very marked reduction in the intensity of the *x*-rays that are shorter than the critical value as compared with those that are longer. The curve in Plate V represents the results of an experiment with a filter of mercury, the marked drop in the curve indicating increased absorption for short wave-lengths at the point corresponding to $\lambda = 0.149$.

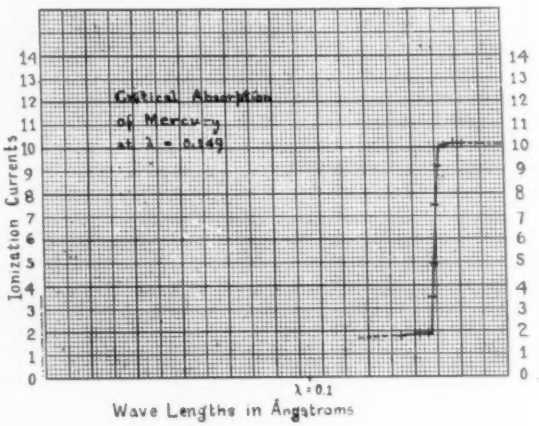


PLATE V.

The exact wave-length at which this abnormal absorption occurs depends upon the chemical element, or elements, used in the filter. Each chemical element has such critical wave-lengths. Evidently if filters are used to cut down the intensity of *x*-rays of long wave-lengths, and thus increase the average penetration of the whole beam of rays, care must be taken to choose filters containing chemical elements that do not have characteristic wave-lengths in the region of the spectrum employed. Otherwise, the effect of the filter will be the reverse of that desired. For purposes of record, Table IV has been inserted.

It contains the values of those critical wave-lengths measured by the ionization method that lie in or near the region of *x*-ray spectra usually employed.[4] A list of all such critical wave-lengths may be found in a report on Data Relating to *X*-Ray Spectra, published by the National Research Council.[3]

As an illustration of the use to be made of this data let us suppose that we are applying a voltage of 115,000 volts to the *x*-ray tube, as in the experiment illustrated in Plate IV. According to the law represented by equation 4, the minimum wave-length produced under these circumstances to much has a value of 12,354 ÷ 115,000,

TABLE IV

CRITICAL ABSORPTION WAVE-LENGTHS OF CERTAIN CHEMICAL ELEMENTS

| Element | Wave-length | Element | Wave-length | Element | Wave-length |
|---|---|---|---|---|---|
| Rubidium | 0.8143 | Indium | 0.4434 | Dysprosium | 0.2308 |
| Strontium | 0.7696 | Tin | 0.4242 | Tungsten | 0.17806 |
| Yttrium | 0.7255 | Antimony | 0.4065 | Osmium | 0.1683 |
| Zirconium | 0.6872 | Tellurium | 0.3896 | Platinum | 0.1582 |
| Niobium | 0.6503 | Iodine | 0.3737 | Gold | 0.1534 |
| Molybdenum | 0.6184 | Caseium | 0.3444 | Mercury | 0.1491 |
| Ruthenium | 0.5584 | Barium | 0.3307 | Thallium | 0.1448 |
| Rhodium | 0.5330 | Cerium | 0.3068 | Bismuth | 0.1373 |
| Silver | 0.4850 | Neodymium | 0.2861 | Thorium | 0.1132 |
| Cadmium | 0.4632 | Terbium | 0.2398 | Uranium | 0.1075 |

which equals 0.107. The spectrum contains all waves longer than this. If we examine Table IV we see that the critical absorption wave-length for such an element as tungsten is .178. If, therefore, we use tungsten as a filter it would cut down *x*-rays of wave-lengths lying between 0.107 and 0.178 to a very much greater extent than wave-lengths longer than 0.178. Tungsten, therefore, would not be a suitable substance to use as a filter. The same is true of lead, platinum, gold, and all the other chemical elements near tungsten in the table. One might use silver, however, which has a critical wave-length of 0.485: for this lies some distance beyond the part of the spectrum employed.

### VIII. CONSTANT VS. VARIABLE VOLTAGE

It has been shown experimentally that the distribution of energy in the *x*-ray spectrum is about the same for a constant voltage applied to the *x*-ray tube as for an alternating voltage.[6] In these experiments no filtration was used. One might expect that for heavy filtration there would be a difference in the distribution of energy. In order to decide the question by experiment I have made measurements with 4.08 mm. of aluminum and 10.2 mm. of aluminum filtration. In order not to produce the K radiation of tungsten and to have a pure, continuous spectrum of *x*-rays, I applied first a constant voltage of 68,200 volts to the tube, and then an alternating voltage, the peak value of which amounted to 68,200 volts. The curves representing the measurements appear on Plate VI.

As in previous cases, the minimum wave-length is the same for both curves. In other words, the peak of an alternating voltage determines the minimum wave-length of the *x*-rays produced. It appears, however, from the curves, that in the case of the constant voltage there is more radiation in the short wave-length *x*-rays, as compared with the long, than in the case of the alternating voltage. An exami-

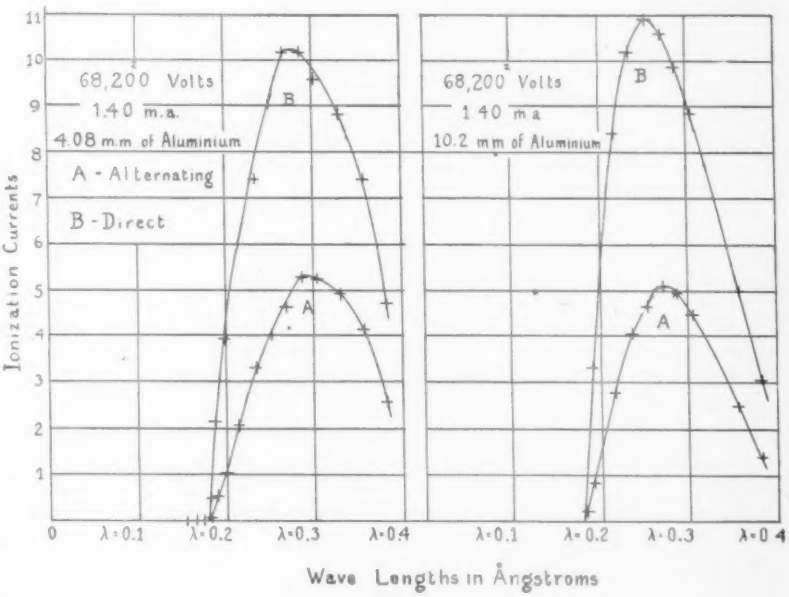


PLATE VI.

nation of the curves indicates that about as much shortening of the wave-length occurs on passing from an alternating to a constant voltage as is produced by increasing the filtration from 4.08 to 10.2 mm. of aluminum. Instead of reducing the intensity of the radiation, however (as in filtration experiments), the constant voltage increases the intensity, as compared with the alternating voltage. The maximum ionization current is more than twice as large for the constant as for the alternating voltage, when the same number of milliamperes pass through the *x*-ray tube.

### IX. EFFECT OF DIRECTION OF *X*-RAYS

As shown in Section VI above, the point representing the minimum wave-length at a given voltage is the same for *x*-rays coming from the tube in a direction normal to the cathode stream as for *x*-rays coming from the tube in some other direction. It has been known for a long time that the rays coming from a tube in the direction in which the cathode rays travel are, on an average, somewhat more

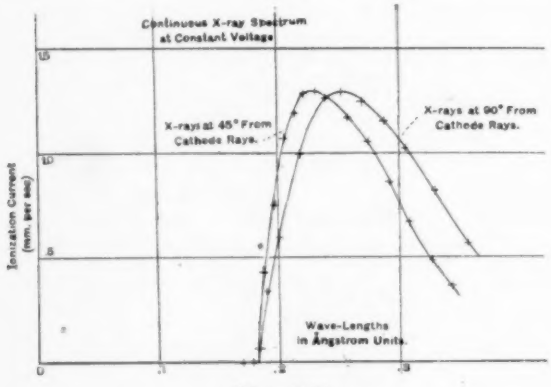
Continuous X-ray Spectrum at Constant Voltage
X-rays at 45° From Cathode Rays.
X-rays at 90° From Cathode Rays.
Ionization Current (mm. per sec)
Wave-Lengths in Ångstrom Units.

Plate VII.

penetrating than in other directions. It has been found by experiments that in the spectrum of these rays there is more energy radiated in the short wave-lengths, as compared with the long, than for rays in other directions.[5] In order to investigate this point in the case of high filtration, I made some measurements with a voltage of 68, 200 volts on rays coming from the tube at right angles to the cathode stream and at an angle of 45° from it. The curves in Plate VII represent the results obtained. There appears to be quite a marked shifting of the curve toward the shorter wave-lengths for the 45° angle. The effect is larger than in the case of a change of filtration from 4.08 to 10.2 mm. of aluminum.

From these experiments it seems probable that the most penetrating beam of rays could be obtained by constructing the tube with a fairly thin target (perhaps water cooled), and by using the rays coming through the target and travelling in the direction of the cathode stream. In this case the target itself would act as a filter. Since, as explained in Section VII, tungsten should not be used as a filter on account of the fact that its critical absorption wave-length lies in the region of the spectrum used, it would be advisable to employ some other metal as a target. Probably molybdenum would be the best.

### X. COMPARISON OF *X*-RAYS WITH $\gamma$-RAYS

It is evidently a question of considerable importance to determine the ratio of the radiation coming from a given quantity of radium (or emanation) to that due to an *x*-ray tube operated under given conditions. If we wish to investigate the direct radiation in these cases, great care must be taken to cut off, as far as possible, all scattered and secondary rays. Figure 4 represents the arrangement of apparatus in some experiments I have performed to investigate this question. In order to reduce the effect of scattered and secondary rays to a minimum, the source of the radiation was placed in one room and the measuring apparatus in another. The direct rays from the source (either a tube containing radium emanation or an *x*-ray tube) placed at A in Plate VI passed through a hole one inch in diameter in a lead plate one cm. thick, and thence through a brick wall, B, 20 cm. thick. The lead plate and brick wall cut off almost all of the stray radiation. A slight amount, however, leaked through in the case of the emanation tube, but its effects were measured and corresponding corrections made for it. After coming through the hole in the wall the rays passed through a glass vessel, C, 10 cm. long and with very thin windows in its ends. This vessel could be filled with water, and thus the amount of

radiation absorbed and scattered in 10 cm. of water could be determined. After coming through the water vessel the rays passed through a hole in a lead plate, D, and thence into an ionization chamber, E. The currents in this ionization chamber could be measured by means of an electrometer, as described in Section II above. The Plate VI records the distances between the various pieces of apparatus. The data obtained in several experiments appear in Table V. Column 1 contains a description of the source of the rays, column 2, the amount of lead traversed by the rays before passing through the hole in the wall, and columns 3 and 4, the ionization currents

TABLE V

| Source of Rays | Filtration Thickness of Pb, Mm. | Ionization Current | | Percentage Through $H_2O$ |
|---|---|---|---|---|
| | | No $H_2O$ | 10 Cm. of $H_2O$ | |
| 50 mc. of emanation..... | 2.0 | 3.36 | 1.44 | 43.0 |
| 50 mc. of emanation..... | 3.7 | 2.88 | 1.28 | 44.5 |
| *X*-rays, 109,000 volts.... | 4.0 | Too small to measure | | |
| *X*-rays, 109,000 volts.... | 3.0 | 3.85 | 0.591 | 15.4 |
| *X*-rays, 109,000 volts.... | 2.0 | Too large to measure | | |
| *X*-rays, 80,000 volts.... | 2.5 | 2.55 | 0.382 | 14.9 |

expressed in arbitrary units. In column 5 appear the percentages of the radiation that get through 10 cm. of water in the various cases. In each *x*-ray experiment 1.0 ma. passed through the *x*-ray tube.

The experimental conditions in these experiments were so chosen as to produce ionization currents of the same order of of magnitude in the case of *x*-rays as in the case of $\gamma$-rays. It appears from column 3 that the rays from 50 mc., after they have passed through slightly more than 3 mm. of lead, produce the same ionization current as the rays from the *x*-ray tube produce after they have passed through the same thickness of lead, if a voltage of 109,000 volts drives a current of 1.0 ma. through the tube. Anyone who has experimented with *x*-rays knows that only an extremely small fraction of the total radiation gets through 3 mm. of lead. Hence, this experiment indicates how enormous must be the intensity of radiation coming from an *x*-ray tube, as compared with that produced by the penetrating rays from a few millicuries of emanation. Further, column 3 in the table shows that a great difference exists between the penetrating powers of the rays through lead coming from the two sources respectively. An increase in the thickness of the lead filter of 1.7 mm. reduces the ionization current due to the rays from the emanation from 3.36 to 2.88 only, whereas in the case of the *x*-rays a change of 1 mm. in the thickness of the lead makes the ionization current either too small to measure or too large to measure with the apparatus as it was set up.

The data of columns 4 and 5 indicate a similar difference in the penetration of the rays from the two sources through water. The increase in the thickness of the lead filter of 1.7 mm. increases the percentage of the radiation that gets through 10 cm. of water from 43 to 44½ only. In other words, such an increase in filtration does not produce much increase in the penetration through water.

In the case of the rays coming from the *x*-ray tube, the fraction that gets through 10 cm. of water amounts to only about 15 per cent, i.e., about one-third the percentage of $\gamma$-rays that gets through the 10 cm. of water. The change of voltage from 80,000 to 109,000 volts increases the percentage that gets through the water from 14.9 to 15.4 only. This experiment furnishes a good illustration of the abnormal absorption of the rays by the lead. The critical absorption wave-length of lead lies in the region of the spectrum of these *x*-rays. The lead almost completely absorbs all the waves shorter than this critical absorption wave-length, so that an increase in voltage does not increase the amount of radiation of short wave-lengths to any very great extent.

### XI. PENETRATION OF HOMOGENEOUS *X*-RAYS THROUGH WATER

In the experiments described in Section X the rays were not analyzed by means of the spectrometer. The beam, therefore, contained rays of a great variety of wave-lengths. I have made experiments with the spectrometer and with the vessel containing the water to see whether or not homogeneous *x*-rays of greater penetration than that recorded in Section X could be

obtained. In order to suppress, as far as possible, secondary and scattered radiation, I placed the water vessel between the *x*-ray tube and the hole in the lead plate and brick wall (Fig. 3), an *x*-ray tube without the side tube being used. It appears that for very short waves (in the neighborhood of .1 ångström) a decrease in wave-length makes very little increase in the penetration. This means that the term $a\lambda^3$ in equation 1 has become small in comparison with b. It is probable, however, that equation 1 represents only an approximation to the truth.

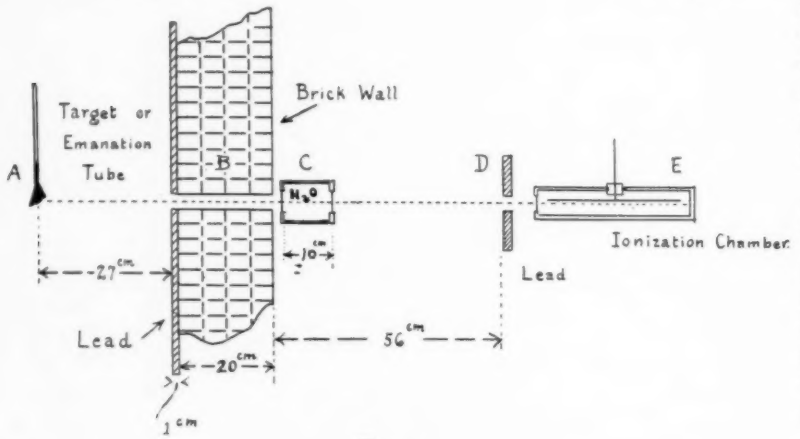


FIG. 4.

In the case of the most penetrating rays that I have been able to produce, about 20 per cent of the roentgen radiation passes through 10 cm. of water.

## XII. SUMMARY

This paper has described (a) an accurate method of controlling and measuring the voltage applied to an *x*-ray tube, (b) a delicate spectrometer for analyzing the spectrum of the *x*-rays, involving very thorough protection of the instruments from disturbances due to stray roentgen radiation and to the high potentials applied to the tube.

It contains the results of experiments on the means to employ in order to reduce the value of the term $a\lambda^3$ in the equation that gives the distance to which the rays travel through matter before half the radiation has been absorbed, namely

$$D = \frac{693}{a\lambda^3 + b} \qquad (1)$$

A *decrease* in $a\lambda^3$ means an *increase* in the penetration, D, of the rays.

The product $V\lambda_m$ (V = voltage in volts, and $\lambda_m$ = shortest wave-length produced in ångströms) is a constant for all voltages and all tubes. An accurate measurement of this important constant has been made (Section VI). It equals 12,354, and appears to be the same for rays coming off in different directions from the tube. From the equation

$$V\lambda_m = 12{,}354 \qquad (4)$$

we can calculate immediately the shortest wave-length in the spectrum produced by a given voltage (either constant or peak), or we can calculate the voltage required to produce waves as short as any given wave-length.

The double valve generating plant described in Sections III and IV produces voltages that are constant enough for fairly accurate measurements. The constant voltage obtained equals twice the peak voltage produced by the transformer.

It appears from the curves shown in the various plates that the *x*-rays, even at constant voltage, are never homogeneous,[2] but that they contain large amounts of radiation of longer wave-length than the minimum wave-length given by equation 4.

From the results described in Section VII we conclude that, in general, the radiation of long wave-lengths may be cut down by filtration more than the radiation of short wave-lengths, and thus, on the average, a shortening of the wave-length may be produced. Although this effect is very marked for the first few millimeters of aluminum used as a filter,[2] yet the shortening of the average wave-length due to an increase of thickness of aluminum from 4.08 to 10.2 mm. amounts to only a few per cent. The curves of Plate III indicate that the wave-length corresponding to the maximum ionization current becomes only 7 per cent shorter when this increase in filtration is made. A 7 per cent

decrease in $\lambda$ means, however, a 20 per cent decrease in the term $a\lambda^3$ of equation 1. The above change in filtration reduces the radiation to about 38 per cent of its original value. We conclude, further, from Section VII that great care must be taken not to choose a filter that has a critical absorption wave-length in the region of the spectrum used, for such a filter would reduce the intensity of the short *x*-rays much more than the intensity of the long *x*-rays. Table IV contains the critical absorption wave-lengths of various chemical elements that lie in the region of the *x*-ray spectrum usually employed.

According to the results described in Section VIII, the minimum wave-length of the rays produced by a constant voltage is the same as the minimum wave-length produced by an alternating voltage the peak value of which equals the constant voltage. On the average, however, the constant voltage produces shorter waves than the variable voltage. Although this effect is small for unfiltered rays,[6] it becomes quite appreciable in the case of high filtration. The curves in Plate VI show that the wave-length corresponding to the maximum ionization current decreases some 7 per cent, if a constant voltage is employed instead of an alternating voltage. A 7 per cent decrease in $\lambda$ means a 20 per cent decrease in the value of $a\lambda^3$ of equation 1. The use of a constant voltage instead of an alternating voltage, therefore, produces about the same shortening of the waves as an increase of filtration from 4.08 to 10.2 mm. of aluminum produces. In addition to the shortening effect the constant voltage produces a radiation of much greater intensity than the alternating voltage.

Although (from Section V) the minimum wave-length appears to be the same for rays coming from the tube in different directions, the average wave-length may be shorter in some cases than in others. It has been known for a long time that the rays coming from an *x*-ray tube in the direction of the cathode particles are somewhat more penetrating than those coming off in other directions. The curves on Plate VII show that (in the case of high filtration) for the *x*-rays passing off in a direction making an angle of 45° from the direction of the cathode rays, the wave-length corresponding to the maximum ionization current is about 10 per cent shorter than for the rays coming off at right angles to the cathode stream. A 10 per cent decrease in $\lambda$ means a 27 per cent decrease in the value of the term $a\lambda^3$ in equation 1.

The results obtained in comparing the ionization currents due to rays from emanation with those from an *x*-ray tube show that the currents due to 50 mc. of emanation are about the same as those due to 1.0 ma. through an *x*-ray tube at 109,000 volts, if the rays pass through a little more than 3 mm. of lead. Since very little roentgen radiation gets through 3 mm. of lead, this indicates how very much more intense the radiation from an *x*-ray tube is than that from emanation.

The results tabulated in Table V show that very little increase in the penetration of the $\gamma$-rays through water is produced by increasing the thickness of the lead filter from 2 to 3.7 mm. and that very little increase in the penetration of the *x*-rays through water is produced by increasing the voltage from 80,000 to 109,000 volts. This latter fact illustrates the effect of abnormal absorption. Further, under the experimental conditions described, the percentage of $\gamma$-radiation that passes through 10 cm. of water amounts to 43 or 44½ per cent, while the percentage of roentgen radiation that passes through the 10 cm. of water amounts to about 15 per cent, i.e., to about one-third of the percentage of $\gamma$-radiation that gets through the water. It must be borne in mind that in these experiments scattered and secondary radiation has been, as far as possible, eliminated.

Experiments on the penetration of homogeneous *x*-rays through water indicate that very little change in the value of D (equation 1) occurs due to a change in the wave-length, $\lambda$, if $\lambda$ lies in the neighborhood of .1 ångström. In the case of the most penetrating rays produced, about 20 per cent of the roentgen radiation passed through 10 cm. of water.

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# THE SUPERNUMERARY PEDAL BONES*

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It is generally taught that the tarsus is composed of seven bones, the astragalus, calcaneus, naviculare, cuboid, and the medial, middle and lateral cuneiforms. This is but partly true. There are in reality almost three times this number of bones, but, inasmuch as they do not occur constantly, are of relatively small size, and were until comparatively recently considered to be sesamoid bones, but little attention has been given to them. Anatomies either do not mention them at all, or else mention only a few of the more important ones in small print at the end of the chapter on osteology. The student of anatomy, in the course of his prescribed studies, never hears mentioned the names of these important, so-called supernumerary bones.

In 1605, Bauhin, the anatomist, described the tibiale externum. Since that time, the same ossicle and other variable bones have been described by many anatomists, chief among whom are Vesalius, Steida, Gruber, Rosenmüller, Morel, Thilinius, Pfitzner and Dwight. Little by little, the presence of these bones has been shown to be due to the ossification of cartilaginous centers which are present in the feet of human embryos. These embryonic feet contain many such centers indicating bones which during development either entirely disappear or fuse with other centers, to represent tubercles or prominences of the well-developed constant bones. In a definite percentage of cases they persist either as independent supernumerary bones, or as well-marked processes attached to the constant bones.

In the course of this metamorphosis a great majority of the cartilaginous centers lose their identity during an early period of development, but certain centers of ossification join other centers and proceed to form a composite bone. When these centers of ossification persist as separate bones, they belong to that class of structures which, for want of a better name, are called the "supernumerary ossicles." The supernumerary ossicle may become connected with one or more of the adjacent bones by a true joint, or may have a ligamentous attachment. More frequently it is actually fused with a neighboring bone, or connected by fibro-cartilage, but yet so clearly marked off on the surface that there is no question as to its identity. Only when it is so completely fused with another bone that it loses its own characteristics is its nature in doubt.

In order to gain a better idea as to the nature of these bones, I have made composite drawings of the foot of an adult, both dorsal and plantar views, which show the supernumerary ossicles in their usual relationships to the constant elements. The variations in size, shape, and position of the individual ossicles are not of sufficient degree to cause any difficulty in their recognition when seen

* Approved for publication by the Surgeon-General.

in the macerated foot or in the roentgenogram, once their general characteristics and positions are fixed in mind (Figs. 1 and 2).

The following is a tabulation of all the supernumerary ossicles which, up to the present time, have been found on dissection and proved to be true bony variants. To this there is but one exception, and that is the secondary astragalus which was seen in a stereoscopic picture, and which the writer has described in another publication. With this one exception all the bones are firmly established as true supernumerary ossicles.

1. Astragalus
   (*a*) trigonum
   (*b*) astragalus secondarius
2. Calcaneus
   (*a*) os sustentaculi
   (*b*) calcaneum secondarium
3. Naviculare
   (*a*) tibiale externum
   (*b*) supranaviculare
4. Cuboideum
   (*a*) cuboideum secondarium
5. Cuneiforme primum
   (*a*) cuneiforme I bipartitum
6. Cuneiforme secondum
   (*a*) intercuneiforme
7. Cuneiforme tertium
   (*a*) os unci (processus uncinatus cuneiformis)
   (*b*) Intermetatarseum
   (*c*) Os vesalianum
   (*d*) Os peroneum

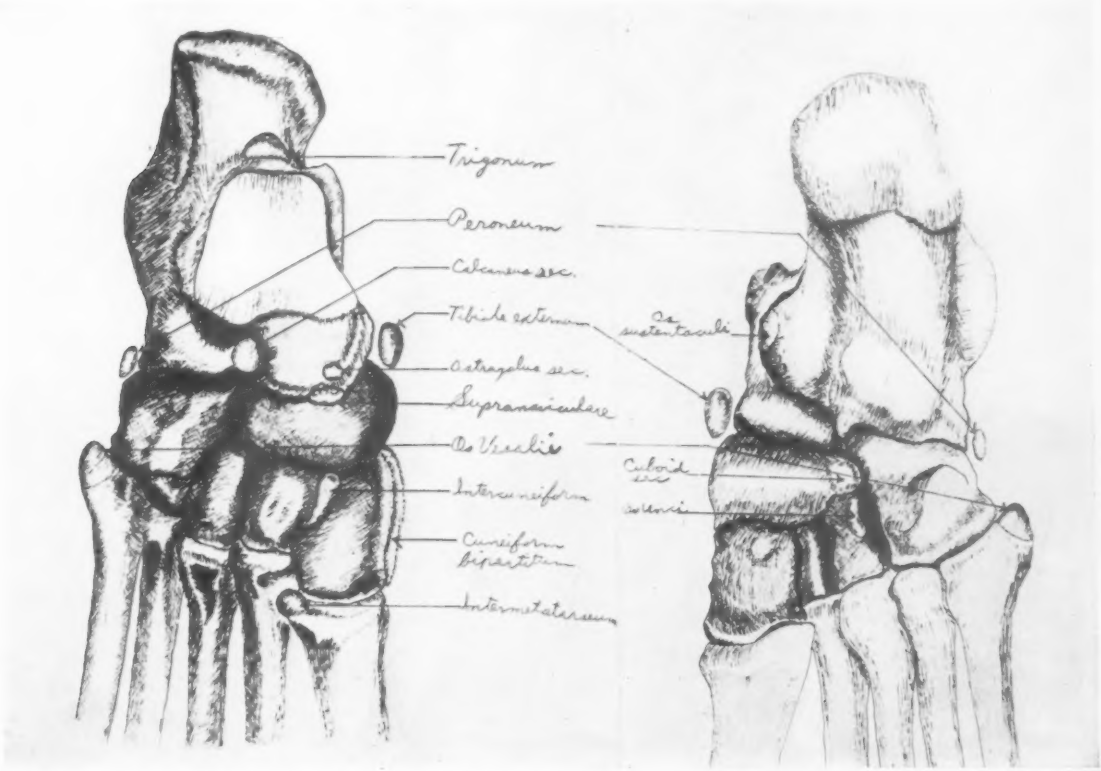


FIG. 1. Dorsal view. Composite foot showing all known supernumerary bones.

FIG. 2. Plantar view. (Same foot as Fig. 1.)

| | |
|---|---|
| Normal bones | 7 |
| Supernumerary ossicles | 13 |
| Total | 20 |

*Trigonum.* This is the best known of the supernumerary tarsal bones, and is probably the one most intensively studied. The first accurate description was by Schwegel in 1858, although it was first recognized by Rosenmüller in 1804. The frequency of the occurrence of this ossicle varies with the

opinions of the different writers. Some consider as the trigonum the ossicle in either its fused or unfused state. Others insist on the independent form. In general it would appear that it can be either found entirely independent, or distinctly marked off on the surface in about 10 per cent of all feet.

The os trigonum may be connected with the astragalus by means of fibrous tissue, or the opposed surfaces of the bones may be covered with a thin line of hyaline cartilage and separated by a joint cavity which may be continuous with the cavity of the posterior astragalo calcaneal articulation. It may be fused with the astragalus, or the only evidence of its original independence may be a groove on the under articular surface which separates the posterior articular surface of the calcaneus into pars propria and pars trigona. In size, the trigonum is usually from 15 to 22 mm. in a transverse direction, and from 10 to 15 mm. in both the sagittal and vertical directions.

Fig. 3. Trigonum.

For presentation in the roentgenogram this bone probably has the most favorable position of all the supernumerary ossicles. In a lateral view of the ankle it will be found at the posterior edge of the astragalus, bordering on the superior surface of the calcaneus (Fig. 3).

*Astragalus Secondarius.* This is a small, oval ossicle lying above and behind the head of the astragalus, near the anterior portion of the neck, apparently posterior to the dorsal talonavicular ligament. There is no record in the literature of this ossicle having been described, other than that reported by the writer, and since it has never been found at dissection, it must be classed with those supernumerary structures which are still considered doubtful. Figure 4 is a reproduction of the writer's case.

*Os Sustentaculi.* This is a small, wedge-shaped bone which comprises the upper posterior end of the sustentaculum tali. Its size is about 10 mm. in a transverse direction, 7 mm. in a sagittal direction, and its greatest thickness about 4 mm. So far as could be found in the literature, there were no cases reported other than the two reported by Pfitzner, who first saw the bone in 1896. It is, therefore, quite rare, and represents an originally independent skeletal piece that has not yet been entirely assimilated by the calcaneus. The upper surface of the os sustentaculi completes the joint surface of the sustentaculum, and articulates with the collum tali. Its under surface coalesces with the sustentaculum.

Fig. 4. Secondary astragalus.

Up to the present time it has not been shown in a roentgen-ray film, and it is doubtful whether it ever will be. Its anatomical position is such that it cannot be shown on standard anteroposterior views of either the ankle or foot. It would seem possible, however, that it might be shown when the foot is in a position about midway between these two standard positions, but probably not otherwise.

*Calcaneum Secondarium.* This was first described by Steida in 1867. Though very few cases have been reported, it probably is not as rare as is commonly supposed. Pfitzner found it 17 times in 840 cases, about 2 per cent. The bone is generally small and of irregular shape. It forms the anterior upper edge of the anterior part of the calcaneus (the so-called processus anterior calcaneii). Its greatest diameter is the transverse. In the well-developed form it is approximately 12 to 15 mm. long, 8 mm. wide, and 5 mm. thick, and stretches as a bridge between the calcaneus and os naviculare. At other times it lies dorsally in the intervening space which is bordered by the calcaneus, astragalus, naviculare and cuboid. Dwight considers the secondary calcaneus to be an entirely different structure, which is not here discussed.

FIG. 5. Calcaneum secondarium (after Lillienfeld).

The bone is fairly well shown in a lateral view in a roentgenogram. Most commonly it is found fused with the calcaneus, as its independent condition is quite rare. Due to its irregular form, confusion with a bony fragment following injury can not always be excluded (Fig. 5).

*Tibiale Externum.* The tibiale externum has been known for many hundred years. It was first described by Bauhin in 1605, and was for many years known as the "sesamoid bone in the tendon of the musculus tibialis posticus." It is a pyramidal-shaped bone, and lies in the medial angle between the naviculare and astragalus, therefore behind the former and medial to the latter. Its base borders directly on the tuberosity of the naviculare; the longest measurement being about 12 mm. and its transverse measurement about 9 mm. The rudimentary forms are somewhat roundish and lie free in the soft tissues. Usually some fibers of the medial end of the end tendon of the m. tibialis posterior, as well as the l. calcaneonaviculare, insert into it.

Its favorable position permits it to be well shown on the film when roentgenographed in the dorsoplantar direction (Fig. 6).

FIG. 6. Tibiale externum.

*Supranaviculare.* This is an extremely rare supernumerary bone which may have been described by Pfitzner, but certainly was by Pirie and Paccini. The writer has examined a patient who showed this bone developed bilaterally. The ossicle is situated on the upper posterior border of the naviculare, and articulates both with the naviculare and the head of the astragalus. It is best shown on the roentgenogram in a lateral view (Fig. 7).

*Cuboideum Secondarium.* The secondary cuboid, first described by Schwalbe, is rarely found as an independent bone. It is usually fused with either the cuboid or naviculare; more frequently with the latter. In fact, the expectation is to find it fused with the naviculare, though its fusion with the cuboid must be kept in

mind. When it is united to the naviculare it is situated at its lower, outer edge, and astragalo-cuboid articulation. At times it is so placed with reference to the naviculare as to be directed proximally into the sole of the foot. More frequently, however, it is attached to the lower part of the naviculare, giving the latter a four-sided characteristic outline. At other times it is so directed as to border on the cuboid.

FIG. 7. Supranaviculare.

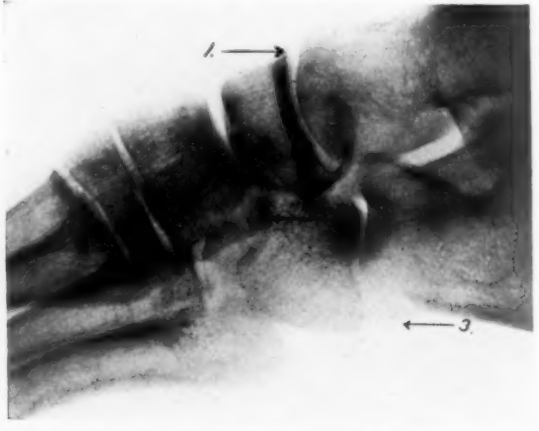


FIG. 8. Lateral view. (1) Supranaviculare; (2) cuboidium secondium; (3) peroneum.

the latter becomes quadrate in form. When fused with the cuboid there results the When this condition occurs, the cuboid and naviculare are in contact, and may be connected by fibro-cartilage.

In connection with the alcaneum secondarium, Pfitzner describes the os cuboideum secondarium as an abnormal process of the cuboid which presents an abnormal articulation between this and the head of the astragalus, but which has not yet been found separate in the adult. In differentiation from the os calcaneum secondarium, he believes that it is situated more plantar and tibialwards, while the latter lies more dorsally and fibular. Probably both of these forms are identical.

Its independent condition is very rare, and is evidenced by the fact that Pfitzner never saw it entirely separated. In the accompanying reproductions it is unusually well shown (Fig. 8 and 9).

*Os Cuneiformis I Bipartitum.* This anomaly was first described by Morel in 1757, and occurs in about 0.3 per cent of all feet. The plane of division is always parallel to the plantar surface of the medial cuneiform, and appears so smooth that any confusion whatsoever with a fracture is out of the question. On the distal surface the line of division is seen to be midway between the dorsal and plantar borders, while on the proximal surface the division is usually into small dorsal and large plantar halves.

The literature has no record of any one having identified it on a roentgenogram, but it should be best seen with the inner side of the foot on the plate, and should not be very difficult to show.

*Intercuneiforme.* The intercuneiform has so far been observed only by Dwight, and so his description must suffice: "This is a small wedge-shaped bone with a dorsal triangular surface situated on the dorsum of the foot close in front of the scaphoid, separating the proximal parts of the internal and middle cuneiform bones, but apparently cut off from the latter rather than from the former . . . The interpretation of roentgenograms of this region of the foot strikes me as difficult. I think I have seen this bone thus shown at least once, but I do not dare to feel sure of the observation."

*Os Unci.* To quote Pfitzner: "In the human family I found only one individual case of a process on the plantar surface of

the lateral cuneiform which exactly corresponds to the processus uncinatus of the cat." Lillienfeld has described a case in which he found a small bone corresponding to the size and position of the processes uncinatus, an os unci. The ossicle is crescentric in shape, so that the concave surface turns toward the cuneiform, while the convex part somewhat covers the naviculare shadow.

it is unfavorably situated for presentation, since in this region the shadows of the neighboring bones are superimposed, and the lines are quite confusing. Perhaps its rarest condition is that shown in Figure 10, where it is seen to be fused with the first metatarsal (Fig. 10).

*Os Vesalii.* The vesalianum is extremely rare. In over 2,000 cases Pfitzner did not see it at all. Gruber saw it 3 times

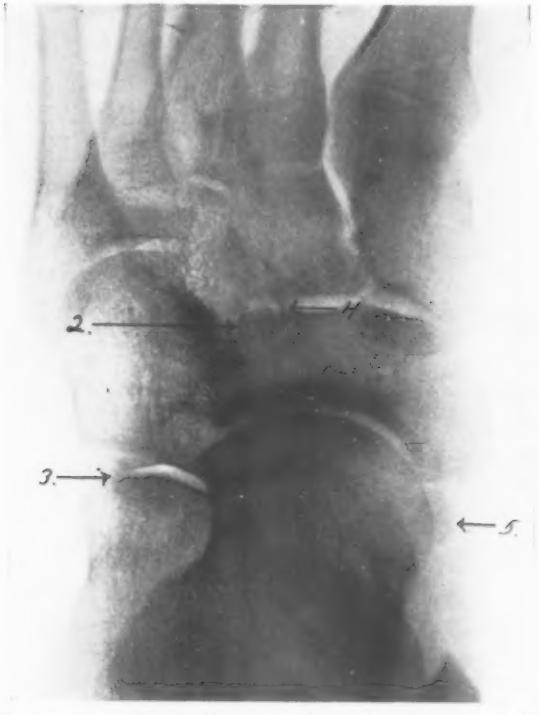


FIG. 9. Anteroposterior view. (Same foot as Fig. 8.) (2) Cuboidium secondarium; (3) os peroneum; (4) os unci; (5) tibiale externum.

FIG. 10. Intermetatarseum (fused).

In addition to its great rarity, this bone is extremely difficult to show on the roentgenogram on account of the numerous confusing lines in the region of the cuneiform bones. It is unusually well shown in Fig. 9.

*Intermetatarseum.* It must be remembered that when Pfitzner calculated a frequency of about 10 per cent of this ossicle he did not, in his classification, consider only the entirely independent ossicles, but included all the three neighboring abnormal processes of bone, which he held to be fused intermetatarsei.

When the bone is entirely independent in about 5,000 cases dissected. It lies on the lateral edge of the foot in the angle be een the cuboid and the 5th metatarsal, and articulates with both. The bone is pyramidal in shape with the apex directed posteriorly. The base is about 8 mm. in a lateral direction and 12 mm. in the dorsoplantar direction. From base to apex it is about 10 mm. The base, which is at a right angle to the long axis of the 5th metatarsal, usually coalesces with a corresponding surface on the posterior end of that bone. Postero-medially it articulates with the cuboid.

It is easily seen in the roentgenogram.

Geist reported seeing it once in 100 cases, and Kleinberg, 3 times in about 300 feet examined by means of the roentgen ray. Either these writers were extremely fortunate, or else their cases were instances of unfused proximal epiphyses. The writer has never seen what could be with certainty called an os vesali pedis in the adult (Fig. 11).

*Os Peroneum.* The peroneum was first described by Vesalius, but more accurately and completely by Pfitzner, who showed

FIG. 11. Os vesalii (after Dwight).

that it is a supernumerary ossicle, and not a sesamoid bone in the tendon of the peroneus longus. In the well-developed form, the tendon of the m. peroneus longus passes over it and is united to it by only a few fibers, while the migrated rudimentary form is entirely enclosed by the tendon. It does not appear to articulate with the cuboid, near whose lower lateral border it is placed. Form and size vary, so that it is difficult to assume a normal. It is frequently subdivided. According to Pfitzner it is seen in about 8 per cent of all feet. It frequently escapes observation, with the plantar surface of the foot on the film, but is best seen in the lateral views with the lateral side of the foot on the film (Figs. 9 and 12).

From the foregoing descriptions of the individual supernumerary bones it is quite evident that most of them appear relatively frequently in the normal foot. It is usually not difficult to determine that an additional structure belongs to this variable class of bones. Where there is a variant present, it is the rule to find other evidence of developmental variations. For instance, if an os vesalianum is present, search for other evidences of developmental variations will usually result in finding other variations, probably not so pronounced, but definitely present, such as an os tibiale externum or os peroneum. Or, less easily recognized supernumerary bones may be present, such as a fused os trigonum or fused secondary os calcis. Such variations are at times very difficult to recognize, but the more we look for them the more often

FIG. 12. Os peroneum (divided).

we recognize them. There is hardly a hand or a foot which has not some slight variation from the so-called normal; and when a distinct supernumerary bone appears, the other evidences of developmental variations are more numerous.

It is evident that the term "supernumerary ossicle" is a misnomer. The bones are not supernumerary; rather, they are lacking from the original plan in the average foot of today. It is probably true that they are reappearing less and less often, but it will undoubtedly be many thousands of years before they disappear entirely. They appear in the feet of mummies found in Egypt. Incidentally, Pfitzner found one of the largest tibiales externum he ever saw in a mummy about 5,000 years old. The other bones were about the same as are found in the foot today. If these supernumerary ossicles are elements which were once constant structures, and there is no doubt that this is true, and they are now appearing only

infrequently in the human foot, our attention is struck by the fact that very little morphological change has taken place in the foot during the last 5,000 years. It may be that the morphological changes were accelerated by the change in posture to the standing position, but all in all, we can but marvel at the antiquity of the human race.

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# THE RECTOSIGMOID APPARATUS*

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## ANATOMICAL CONSIDERATIONS

THE iliac colon extends from the crest of the ilium to the inner border of the left psoas muscle. It is the only portion of the lower colon that is always accessible to palpation. The pelvic colon forms a freely movable loop, varying in length from 5 to 33 inches, the average length being about 17 inches. It has no constant position, but in its most typical arrangement passes from the termination of the iliac colon at the inner border of the left psoas muscle, loops to the right, and ends in front of the third sacral vertebra, where its junction with the rectum forms the pelvirectal flexure. The rectum is between 4 and 5 inches in length and lies in contact with the sacrum and coccyx. At its termination the rectum bends slightly backwards and merges into the anal canal. The anal canal, about 1 to 1¼ inches in length, is directed downwards and backwards, forming almost a right angle with the rectum. It forms a narrow canal with longitudinal folds of mucous membrane, surrounded by the muscle fibers that form the external and internal sphincter apparatus.

It is impossible to enter into a description of the diseases that involve the lower intestinal tract without some consideration of the topography of the entire colon. The usual description above applies very well to the average normal subject as the organs appear at autopsy. In the living individual, the anatomical relationships are not constant, but vary with the structure or bodily habitus of the individual.

Mills, in his work on habitus, has demonstrated that the visceral contents of the abdominal cavity conform to certain definitely recognizable anatomic types. The most striking variation is shown in the differences in the position and form of the stomach. Mention may be made here of the long narrow fishhook-formed stomach of the asthenic, extending to the pelvis, in contradistinction to the almost transverse high stomach of the hypersthenic.

The colon also shows very marked variations corresponding to the bodily habitus of the individual. In the hypersthenic, the sigmoid loop or pelvic colon is high above the pelvic cavity, and really presents but one curve almost circular in character. In the sthenic, the loop is more markedly S-shaped and is contained partly in the pelvis. In the asthenic, a portion of the transverse colon and the pelvic colon are massed together in the pelvic cavity (Figs. 1, 2 and 3). In each instance, the position assumed by the colon corresponds to its particular anatomic type and is not to be considered as pathological. Therefore, from a clinical standpoint, the consideration of the form and position of the lower colon presents, a priori, a very pertinent question, namely, does the colon conform to the bodily habitus, or is there a variation from the individual's anatomic type? For example: the pelvic colon of the asthenic may be pushed out of the pelvis by a tumor mass, or the hypersthenic colon may be tied down in the pelvic cavity by inflammatory processes.

The rectum, also while immovably fixed, shows certain variations corresponding to habitus. In the asthenic type, the anal canal is short, located near the coccyx, and the proctoscope enters at once into a large capacious ampulla. In the hypersthenic individual, the anal canal is much longer, situated further from the lower spine, and proctoscopy reveals a relatively much smaller ampulla. In many hypersthenic individuals I found, by actual proctoscopic measurement (the patient in the knee-shoulder position), that the anal canal was from 2 to 2½ inches in length, while that of the asthenics varied from 1 to 1½ inches in length.

The variation in form, observable in the different anatomic types, is not more striking than the differences exhibited in function. In this connection, one may mention the evident tonicity of the colon in the hypersthenic as compared with the extreme atony of the asthenic colon. The rate of

* Read at a Meeting of the Gastroenterological Society, Boston, June 9, 1921.

motility is high in the hypersthenic, low in the asthenic, intermediate in the sthenic. It may be physiological for the hypersthenic to defecate two or three times daily, while in the asthenic, the rate may be normally so slow as to permit an evacuation but once in two days. The intestinal tube of the sthenic and hypersthenic is well adapted to the high energy requirements of individuals exhibiting this structural type. On the contrary, the intestinal tube of the asthenic with its atonic character, low position and slow rate of motility, places the asthenic individual at a disadvantage in the machinery required for the production of bodily energy.

A predilection for the development of certain pathological conditions may be associated with habitus, e.g., the asthenic is notably predisposed to colonic stasis and more frequently presents the syndrome which is usually termed "autointoxication." Moreover, the pelvic colon, from its low position, is more likely to become involved in pelvic inflammatory processes. On the other hand, the condition known as diverticulosis occurs more frequently in hypersthenics and sthenics.

William J. Mayo[2] has made a very careful study of the rectosigmoid apparatus. He has shown that it consists "of 3½ inches of the intestinal tract, which includes the terminal 2 inches of the sigmoid and the proximal 1½ inches of the rectum." It is the narrowest part of the large intestine and is more often the location of pathological processes than any part of the gastrointestinal tract excepting the stomach and duodenum. Mayo's study is based upon dissections in 46 cadavers. The terminal sigmoid contracture was found in 80 per cent of cases examined. Mayo has shown that the rectosigmoid apparatus is controlled by the pelvic plexus of nerves which is made up of a variable number of sympathetic ganglia joined from above by spinal nerves from the lumbar region and from below by the spinal nerves from the sacral region (Fig. 4).

FIG. 1. Colon in individual of asthenic habitus. This colon is to be regarded as normal for this type. Note that the transverse colon descends well into the pelvis.

FIG. 2. Colon in individual of sthenic habitus. This is the position occupied by the transverse colon in individuals of this type. Note the pelvic colon is well within the pelvis.

Langley[3] and others have shown that nerves derived through the hypogastric plexus are inhibitory in character, while those from the spinal and sacral nerves produce contracture of the muscle-fibers of the intestine upon stimulation.

FIG. 3. Normal colon in individual of hypersthenic habitus. Note that the pelvic colon is really well above the pelvis representing the characteristic position for this type.

Keith[4] has shown that the smooth muscle-fibers in this region have the power of originating contraction and that impulses are collected in certain neuromuscular nodes and correlated.

Mayo and Hurst both are of the opinion that the failure of coordination in early life results in the so-called idiopathic dilatation of the colon, or Hirschsprung's disease. This disease is, therefore, according to Mayo, similar in origin to cardiospasm at the cardiac orifice and ileocecal valve stasis. Hurst[5] has suggested the name of *pelvirectal achalasia* instead of Hirschsprung's disease (Fig. 5). According to Hurst, the active relaxation of the circular muscle-fibers at the pelvirectal juncture fails to occur, and a spasm is originated, which leads to partial obstruction with consequent dilatation and hypertrophy of the pelvic colon. The colon, when once dilated, produces a kink by overhanging the undilated portion below, thus producing increased difficulty in defecation, progressive accumulation of fecal matter and progressive dilatation and hypertrophy of the muscle-fibers of the colon, finally

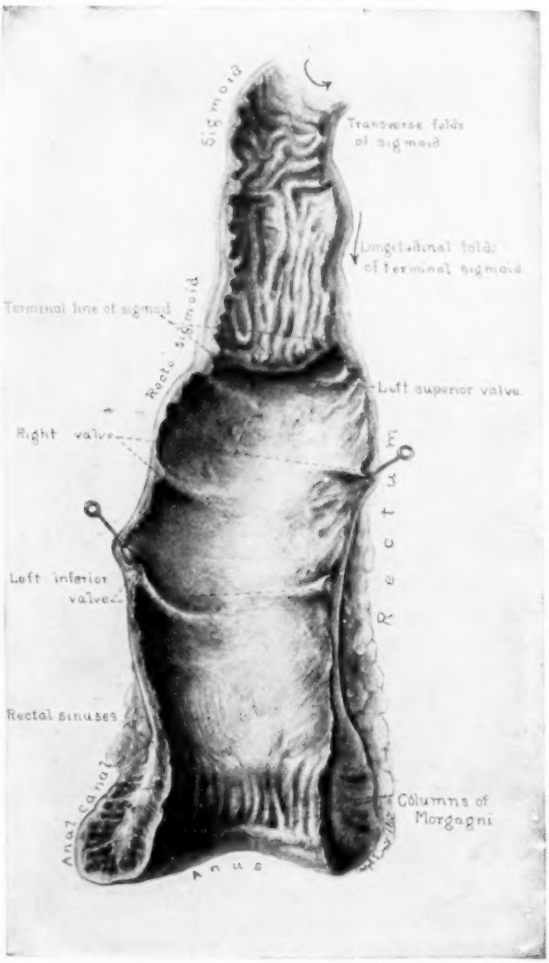


FIG. 4. Terminal sigmoid, rectum and anal canal from inside. W. J. Mayo. Courtesy of *Surgery, Gynecology and Obstetrics.*

resulting in broken compensation with the loss of peristaltic power.

## PHYSIOLOGY

Mayo's anatomical studies have led him to the conclusion that the rectosigmoid apparatus is a definite mechanism, which retards the fecal current and prevents continuous progress of the intestinal contents into the rectum. Hurst, who ex-

amined a large number of young adults, comes to the same conclusion; he further states that normally the rectum does not contain fecal matter, except during the act of defecation. At other times the fecal column is prevented from entering the rectum by the tonicity of the rectosigmoid apparatus.

The studies of Hurst,[5] Holzknecht,[6] Barclay,[7] Case,[8] and others disclose that Hurst has demonstrated that about thirty-three hours' time is required for a meal to be entirely evacuated from the gastrointestinal tract. Food taken nine hours before the act of defecation should reach the splenic flexure and part of it appear in the feces. These figures represent the time required for the average healthy individual at active muscular work. Modifications must of course be made for

FIG. 5. Hirschsprung's disease in a child aged ten. Note small rectum and huge over-hanging pelvic colon.

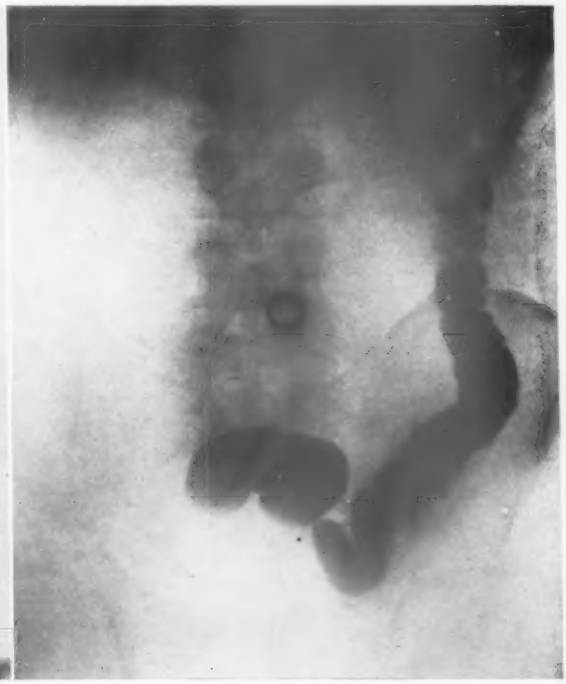

FIG. 6. An enema of 5 ounces of magnesia sulphate solution carrying 35 grams of bismuth subcarbonate. Plate taken two minutes after injection.

the colon is emptied by a series of mass movements. When the fecal column which has been held up at the rectopelvic juncture enters the rectum the desire to defecate is provoked. As Hurst[9] has shown, this desire is not due to stimulation of sensory nerves, inasmuch as they are absent in the rectum except in the mucosa of the anal canal. The reflex is established by means of the "muscle sense" of the distended rectum. The first mass movement empties the rectum and part of the pelvic colon. Secondary mass movements occur and continue until, under normal conditions, the entire large intestine below the splenic flexure is completely emptied.

the asthenic type who habitually have a slower rate of colonic motility, as well as the hypersthenic whose motility is higher than the average individual, as pointed out by Mills in his work on habitus.

While roentgen-ray examination is the best means to determine colonic motility, simpler tests are available, e.g., a 5 gr. carmine capsule or 2 charcoal tablets given with the evening meal should appear (trace at least) in the feces evacuated the following morning. The second morning the entire stool should be colored by the carmine or charcoal. On the third morning there should be no trace of the coloring matter in the feces.

In corroboration and amplification of the work of Mayo and Hurst, the writer has examined a large number of patients, both normal and abnormal, by means of the sigmoidoscope, and has made the following observations:

1. After normal defecation in the morning the rectum contains either no fecal matter or only slight traces adhering to the mucosa.

FIG. 7. Barium meal twenty-four hours after ingestion.

FIG. 8. Same case as Fig. 7. Plate taken one-half hour after injection of magnesia sulphate solution and ten minutes after defecation.

2. The normal rectosigmoid apparatus as viewed through the sigmoidoscope includes from 2 to 3 inches of the bowel and it can be seen to alternately contract and dilate synchronous with respiration.

3. Normal cases present considerable variation in the tonicity of the contracture. It is always possible to pass a ⅝ inch caliber tube through it.

4. Normal cases examined in the morning prior to the act of defecation reveal the fact that the fecal column is above or just engaging the rectosigmoid area.

5. The formation of the feces probably occurs in the iliac colon. This is particularly true of the fragmentary form of constipation in which small, hard, round masses appear in the feces.

### PATHOLOGY

Mayo has pointed out that in an investigation of the last 100 specimens of cancer of the rectum and rectosigmoid removed consecutively at St. Mary's Hospital, it was found that 63 per cent of the growths involved the rectosigmoid, 30 per cent the rectum only, and 7 per cent the anal canal.

As the writer[10] has shown in previous communications, polypi are frequently found at the rectopelvic angle, also various forms of pus infections often occur; furthermore spasms or hypertonic contractures of the apparatus are a frequent cause of obstinate constipation, a condition which I have described as sigmoidospasm. The writer[11] has further demonstrated that a solution of magnesium sulphate applied directly to the contracted area will bring about relaxation of the contracture; if this treatment be continued for a period of weeks or months it will result ultimately

in the correction of the spasm and restoration of colonic function. The majority of the cases of sigmoidospasm are associated with a contracture of the iliac colon; however, they may exist independently of each other. The iliac colon is of extreme interest; it is always palpable; under normal conditions it can be made to contract under the palpating fingers as a rather firm finger-like cord. The contracture will, however, not be persistent, but will relax from time to time. In atony of the iliac colon no such contracture can be elicited by palpation. In spasm of the iliac colon we find the presence of a finger-like cord which cannot be made to relax and which is often tender to pressure. The iliac colon can be reached by injecting the magnesium sulphate solution by means of the sigmoidoscope and a soft rubber tube, with the patient in the knee-chest posture.

Recently we have been working with atonic conditions of the rectosigmoid apparatus and iliac colon. When magnesium sulphate is taken into the stomach it is partly converted into sodium sulphate and magnesium carbonate, substances which increase the contractile phase of peristalsis, according to Meltzer.[12] The remaining unconverted portion of magnesium sulphate stimulates the inhibitory or relaxing phase of peristalsis, thus producing the well-known rush movement of a dose of epsom salts. Meltzer's definition of tonus is as follows: "The resultant effect of the antagonistic action may be manifest at the same place and at the same time. This is tonus. The degree of character of the tonus depends on the preponderance of one or the other factor."

Goldschmidt and Dayton[13] have shown that the colonic wall is impervious to the passage of magnesium sulphate or sodium sulphate; therefore, there can be no possible danger in using these salts in the bowel. They have demonstrated that hypertonic solutions of these salts increase in volume and decrease in concentration approaching the blood level. Solutions of concentration nearly iso-osmotic with the blood show little change in volume. Hence there is free

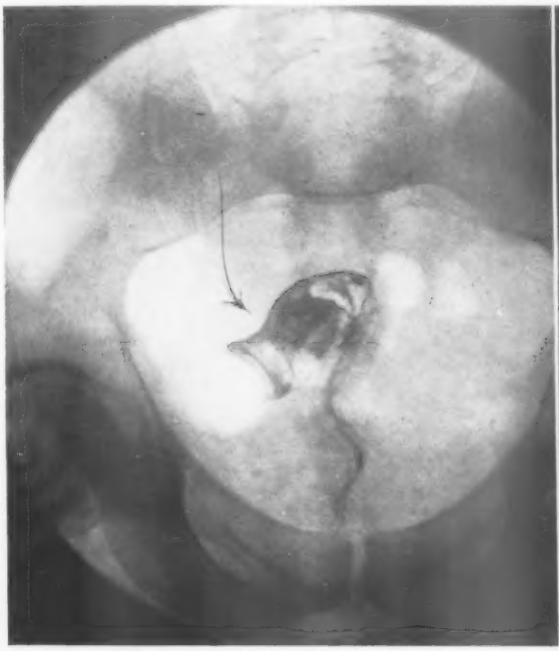

FIG. 9. Insufflation of bismuth subcarbonate. Showing normal rectosigmoid apparatus in stage of relaxation.

FIG. 10. Showing normal rectosigmoid apparatus in stage of contraction after insufflation of bismuth subcarbonate. Note the outline of the collapsed rectum.

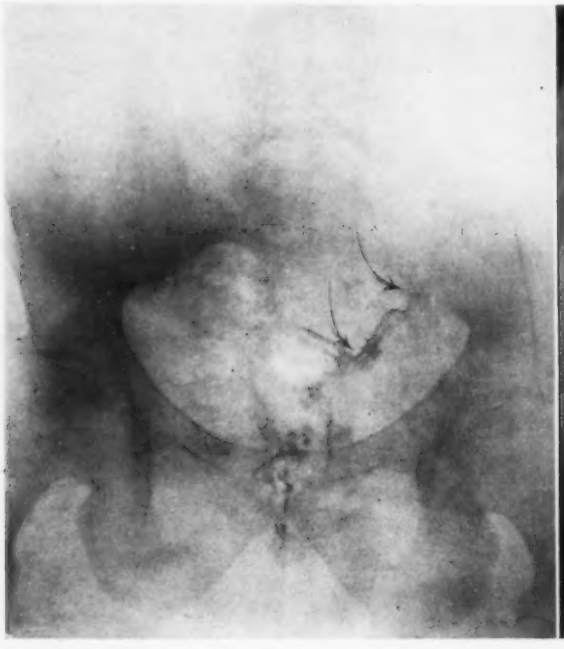

FIG. 11. Insufflation of bismuth subcarbonate outlining a definitely contracted rectosigmoid apparatus. Note the outline of the rectum which is partially gas filled.

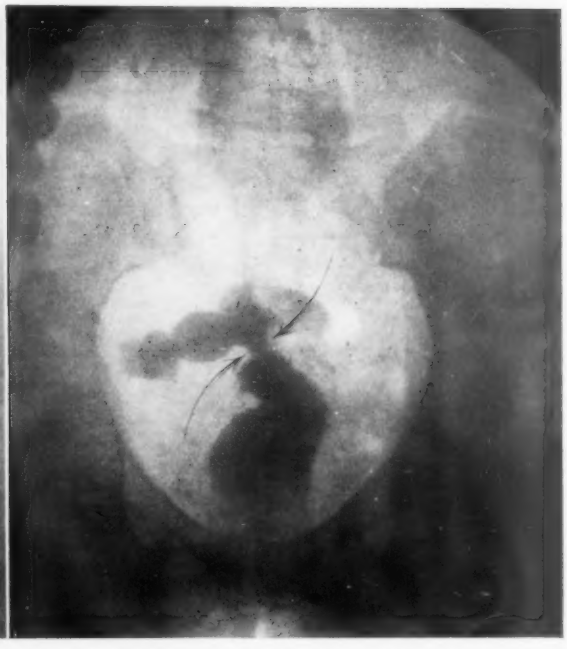

FIG. 12. Barium enema showing outline of the rectum and a portion of the pelvic colon. The narrow connecting part is the rectosigmoid apparatus. Patient had pelvic abscess many years ago: resulting exudate fixed the rectum and colon in this position.

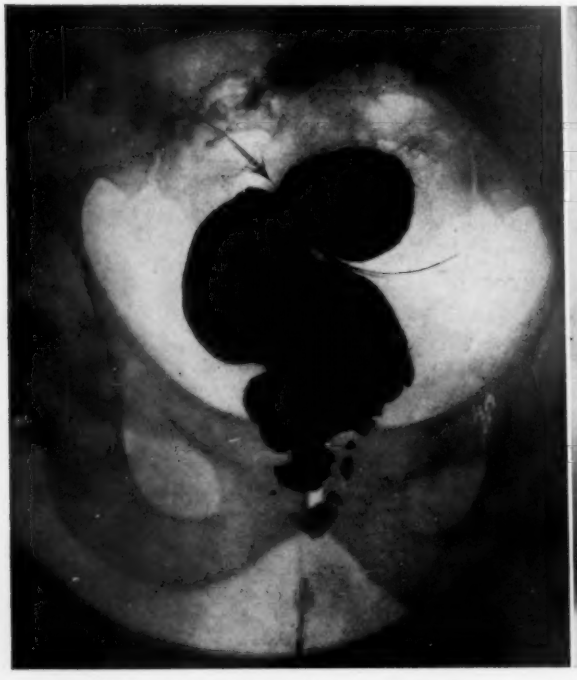

FIG. 13. Normal rectosigmoid apparatus in stage of partial contracture. Verified by sigmoidoscopy.

FIG. 14. Colon after barium meal fortunately depicting a contracted rectosigmoid apparatus, verified by sigmoidoscopy.

passage of water with no diffusion of the sulphates. Sodium chloride solutions, on the other hand, diffuse freely from gut to blood and vice versa. In cases of extreme atony, I used sodium sulphate and found it produced painful contractures without much result in producing defecation. Equal parts of a 25 per cent solution of magnesium sulphate and sodium sulphate have, on the other hand, given us very remarkable results in producing defecation in many cases of atony of the rectosigmoid apparatus, pelvic and iliac colon (Figs. 6, 7 and 8).

During the past year we have been using this method as a routine treatment in atonic cases of long standing, and we find that, in many cases, restoration of the contractile power of the rectosigmoid apparatus and pelvic colon occurs. The most severe forms of atony of the rectum with complete absence of the rectosigmoid apparatus are greatly benefited by a daily enema of the combined salts. This enema is also of great value in post-operative atonic conditions of the lower colon. In cases of post-operative *contractures* the solution of magnesium sulphate alone should be employed.

Visualization of the rectosigmoid apparatus by means of the roentgen ray presents extreme difficulties. The anatomic relationships are such that one rarely secures a view fluoroscopically. The plate method is equally disappointing: we have attempted to secure views by having the patient assume different postures, with but little success. We must recall the fact that we are dealing with an elastic tube that is frequently changing its position, that is overhung and obscured by loops of iliac colon and that is alternately contracting and dilating in a rhythmic fashion. The inconstant and ever-changing anatomic relationships make it impossible to establish normal standards.

The opaque meal (feed test) is absolutely unreliable, inasmuch as it will frequently give the impression of contracture or atony of the bowel when, as a matter of fact, the roentgenogram merely portrays the temporary physiological phase of relaxation or contracture.

By means of the opaque enema roentgenologists have established quite definite standards, and are able to distinguish various fixed types of colon. The enema, however, canalizes the rectosigmoid region even in cases of spasm; the colon gradually fills, and finally the enema fluid distends the rectum as well as the rectosigmoid. Even in the rare instances in which this region will be visualized on the plate, no narrowing or contracture will be in evidence.

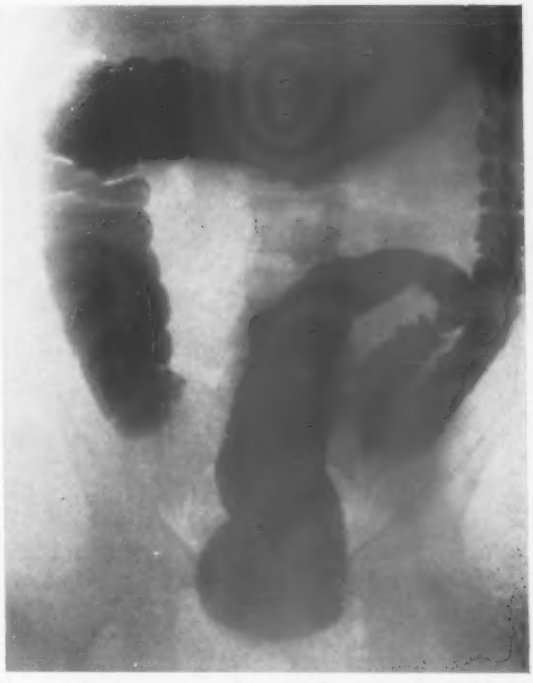

FIG. 15. Barium enema showing absence of rectosigmoid apparatus. This appears to be a definite type of colon in which there is no line of demarkation between the rectum and pelvic colon. We consider it a characteristic type. The resulting constipation is exceedingly obstinate in character.

It is, therefore, obvious that sigmoidoscopy is the only reliable method by which the condition of the rectosigmoid apparatus can be ascertained. We have, however, been able to secure quite good views of the rectosigmoid region by the following method: The patient is placed in the knee-chest posture and insufflations of bismuth subcarbonate made by means of a powder blower through the sigmoidoscopic tube. He is then placed in the dorsal position and immediately plated (Figs. 9, 10 and 11). Very excellent views of the rectosigmoid may at times be secured in patients who have had severe pelvic inflammatory

processes. The resulting exudate involves the wall of the bowel, impairs its elasticity, fixes its position and thus renders it a very good subject for the roentgen ray (Fig. 12). Other illustrations are shown depicting the rectosigmoid region, and are to be regarded as fortunate accidents occurring in the course of a large number of observations* (Figs. 13, 14 and 15).

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* I wish here to express my indebtedness to Dr. R. Walter Mills, without whose aid and valuable suggestions this work would not have been possible. My thanks are due to Dr. L. E. Printy and Dr. Frank R. Finnigan for much of the sigmoidoscopic work.

# ROENTGENOLOGICAL FINDINGS IN MONGOLISM*

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THE study, which forms the basis of this report, was inspired by an article which appeared in "The Archives of Neurology and Psychiatry" by Dr. W. Timme, entitled "The Mongolian Idiot." In this article, he described changes in the outline of the sella turcica, in 23 cases of Mongolism which he believes to be characteristic of this condition. The findings in our own cases have been so at variance with this author's conclusions, that we feel justified in making a brief preliminary report at this time, notwithstanding that the work is as yet incomplete.

Mongolism or Mongoloid Idiocy is characterized by the facial configuration of these patients, which is very like that of the Mongolian races. At the present time the condition is generally held to be a distinct disease entity, although there are still some endocrinologists who consider it but a type of infantile myxedema. However, there are marked points of difference between Mongolism and myxedema, one of the most striking being the difference in skull conformation. The Mongoloid is a round head and the skull is small. The myxedematous case is characterized by a large skull which is usually brachycephalic. The peculiar expression of the face giving the condition its name, is due to the oblique, slit-like palpebral fissures, the small button-like nose and the high zygomatic arches. The tongue is not usually increased in size as in myxedema, but is furrowed. The ears are small and set well back on the head. The body is usually well proportioned and the neck is not shortened as in myxedema. The skin is smooth and moist. One of the most striking features noted in this condition is the shortening of thumb and little finger. These patients may be somewhat stunted in height, but this feature is perhaps less constant and less in degree than in myxedema. While there is a general retardation in bone development, the bone nuclei appear at about the normal time, according to Falta. Closure of the fontanelles and sutures is abnormally delayed. Dentition also occurs

* Read at the Midwinter Meeting, Eastern Section of The American Roentgen Ray Society, Atlantic City, N. J., January 26–28, 1922.

late and irregularities of the teeth are common. These children are all mentally deficient, but are cheerful, lively and mischievous.

According to Timme, in 23 out of 24 cases of Mongolian Idiocy, the roentgenograms of the skull showed an excavation under the anterior clinoid processes in the anterior part of the pituitary faucae. He attributes this finding to changes in the anterior lobe of the hypophysis. The extension of the excavation to the optic groove, he believes the basis of certain eye-findings which were present in his cases, namely, an unequal graying of the optic discs on the temporal sides; also, in certain cases, the disc was apparently edematous. On the basis of this hypothesis, that is, anterior lobe disturbance, he suggests the use of anterior lobe extract, combined with whole gland feeding and thyroid in small doses in the treatment of Mongoloid idiocy.

It is not our purpose at this time to deal with the clinical aspects of this condition nor question the validity of the etiology suggested, as this phase of the subject will be reported at a later date by my associate, Dr. T. A. McGraw, Jr. The roentgenological signs in Mongolism, however, we have attempted to review carefully in a series of of typical cases. The material at our disposal consisted of about 50 cases at the Michigan Home and Training School, Lapeer, and 5 private cases of Dr. McGraw's. It must be stated that the study is not entirely complete, but sufficient material has been examined to justify the conclusions which are reported herewith.

The roentgenological findings in Mongolism can be considered under two heads, namely, those which relate to the general skeletal formation and those which are concerned with the sella turcica itself. Under the first head, our findings may be summarized as follows: The cranium of the Mongoloid is small; in many cases it might be classified as microcephalic. It is dolichocephalic in shape and the cranial bones are uniformly thin. The suture lines were frequently separated, and in many cases irregular rarified areas occurred along the edges. The acral parts, particularly the nose and maxilla are poorly developed. As will be noted, these findings are characteristic of general retardation of bone development. The only condition which may be considered as in any way characterizing the roentgenological picture of the disease under this head, is the disproportionate developmental deficiency on the part of nose and maxilla. Schuller emphasizes this point and suggests the term "acromicria" in apposition to acromegaly in which we find the most extreme development of these parts.

As regards the sella turcica, our findings were far from uniform. The sella differed in shape, in about the same ratio as in normal individuals. It was quite uniformly small, as might be anticipated, when one considers the size of the Mongoloid head. In this regard it may be stated, that we are convinced after a study of a fairly large number of heads during a period of four or five years, that the size of the sella is of relatively little diagnostic importance in the absence of definite erosion; and furthermore, that both the size and shape are influenced by the size and shape of the skull, and particularly of the cranial base. In this series of Mongoloids, not a few of our cases showed the appearance described by Timme. On the other hand, many of the most characteristic cases clinically were negative. Following this work we reviewed many of our routine plates in our office covering a variety of different conditions, the majority of which were normal. In these cases we found this condition appearing quite as consistently as in our Mongoloid series. It should be obvious, therefore, that whatever the cause of this appearance, it is neither constant in Mongolism nor confined to that condition alone. That it is not due to erosion is quite evident, I believe. On every plate I have seen, the cortical bone of the sellar floor, planum sphenoidale and anterior clinoids are intact. Observation on the normal dried skull has shown that it is possible to reproduce this appearance on the roentgen-ray plate by a slight variation of the angle in the central ray. This produces a slight notch-like recess, which runs forward beneath the shadow of the anterior clinoid process

and is outlined by the lower border of the anterior clinoid process above and the lateral margin of the planum sphenoidale below. Not infrequently one or both clinoid processes rise considerably above the roof of the sphenoid and in these instances even the most accurate lateral projection will produce this same appearance. So far in our study we have been unable to find any consistent change in the sella turcica in cases of Mongolism which can be considered definitely pathological. We are thoroughly convinced from this investigation as well as from former studies with the feeble-minded, that fairly extensive changes in the way of enlargement of the pituitary body may occur without involving the sella. The constant study of lateral plates has, we fear, caused us to lose sight of the fact that the sella turcica possesses a transverse as well as an antero-posterior diameter. It takes only a casual study of the floor of the skull and the pituitary fauca to realize that the anterior clinoid processes are quite widely separated and can only be involved by extraordinary enlargement of the pituitary body which is found in tumors of that gland. It is also quite evident that involvement of the anterior clinoid from pressure can hardly occur without eye-symptoms, the result of pressure on the optic nerve. To sum up our observations on Mongolism we may state that in our opinion there is no single characteristic roentgenological sign in this disease, and the only departure from normal is a generalized delay of bone development. This feature, except for a slight selective character on the part of the nose and maxilla, is common to a number of other diseases, some of endocrine origin and others due to obscure causes.

# STANDARDIZATION OF ROENTGEN-RAY REPORTS*

BY P. M. HICKEY, M.D.

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AT a recent surgical congress where a symposium was held on the diagnosis and prognosis of sarcomata, there were read several reports on the roentgen-ray examinations of bone tumors occurring in a well-known hospital during a period of ten years. From these reports, it was difficult to determine, in the majority of cases, the actual bone condition encountered. Practically none presented definite ideas of the bone pathology. The diagnoses advanced were given in a nomenclature which evidently varied with the nomenclature used by the different physicians who had written the reports. One could not help feeling that they had been written in a very haphazard fashion, without much regard to scientific accuracy. The audience natura ly came to the conclusion that in the particular hospital referred to, the statistics in regard to sarcoma, when viewed from the roengten-ray standpoint, possessed very little value. Furthermore, the surgeon who quoted these reports made the statement that he thought this particular institution was no more deserving of criticism in this regard than many other large hospitals.

The writer of this paper after listening to these reports and to the surgeon's criticism, felt that an investigation of this question was warranted. Accordingly, a circular letter was sent out to the members of the American Roentgen Ray Society asking that sample reports of roentgen-ray examinations of different parts of the body be sent in for study. A generous response was rece ved and a large number of reports are on file, which cover examinations of the skull, the mastoids and sinuses, the chest, and the bones for fracture and bone tumor.

While no attempt, as yet, has been made throughly to classify these reports, the writer wou d state that after going over them superficially, he is convinced that many could justly be criticized.

On comparing reports covering roentgen-

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 26–28, 1922.

ray examinations with reports made by pathologists on pathological tissues, we have been impressed with the general inferiority of the roentgen-ray report. In making this statement, I do not wish to be understood as criticising the conclusions or the diagnoses made in these reports, their accuracy comparing well with that of the pathological reports.

The superiority of the pathological reports, when viewed from the standpoint of form and accurate description, is due to the better training of the pathologist. The average pathologist receives a long course of training under competent professors, which teaches him to describe the appearance of the material submitted for examination, and requires him to make drawings of specimens and label the various types of tissues described.

The inadequacy in roentgen-ray reports is due to the present inferior methods of instruction, and to the fact that few colleges demand of their students in roentgenology, accurate descriptions or drawings.

A study of present non-standardized methods of instruction in roentgenology in our American medical colleges reveals the fact that many of the institutions still give a short course of lectures only, without familiarizing the student with the routine of plate examinations and plate descriptions.

One of the functions of the American Roentgen Ray Society is to present to the medical colleges the shortcomings in their methods of study in roentgenology, and to make suggestions as to how these shortcomings can be remedied.

To return to the reports which were sent in, I would like to state that in only a few cases were they so worded that the reader could form from the descriptions a diagnosis of the conditions present. It then follows that in order to make our reports more valuable they should be written in a manner and with a nomenclature which would convey distinct ideas as to the conditions present. Such a system of reports is, of course, of the utmost importance in hospital work; that is, in hospitals which conform to the present high standard.

Judging from some of the letters received, I would conclude that not all the members of the American Roentgen Ray Society recognize the necessity of having reports conform to a certain standard of excellence. Some evidently prefer to inject into their reports their own individual style. Nevertheless, reports filed in hospitals should be scientifically accurate and should follow an accepted nomenclature, so as to have value in a statistical sense. Individual style in reports usually means eccentricity. Such reports may be sufficiently valuable as to diagnosis; but they do not carry the importance that a simple concise statement does.

In going over the reports of fractures, we were unable always to visualize the type of fracture from the report. For example; from one hospital, we received a report which read as follows: "Comminuted fracture of the tibia and fibula, in good position." Another roentgen-ray report read: "There was a fracture of the tibia, and the cast should be removed in ten days." A simple statement that there is a fracture of the lower end of the radius is usually confirmatory evidence of what the patient has known since the accident, and does not give the surgeon any scientific information about the type of fracture. The shorthand type of reports often assumes to advise as to whether further manipulation is necessary. We scarcely think there is any ground for argument that the roentgen-ray report in a question of fracture should give a clear-cut description, so that anyone reading it would have a definite idea of the traumatic pathology present.

If one wished to make a statistical study as to the comparative value of different lines of surgical procedure in the treatment of fractures of the lower end of the radius, the handicap would be formidable if one based his study on many of the reports which are found in our hospitals.

In the reports upon bone tumors, we found a considerable variation in the types. Most of them gave fragmentary descriptions of changes from normal, and conclusions, which, while probably correct, left the impression that they were reached by a process of intuition rather than by a

line of scientific reasoning, the result of deductions from the pathological data observed.

Reports upon the chest varied from one, which described and diagnosed the condition n two words, to lengthy reports, which, after describing the conditions, took up the question of prognosis and finally gave advice as to the method of treatment. It is only fair to assume that advice as to the treatment of a patient with a pulmonary condition should be based on the data obtained from complete observation and examination, and not upon a roentgenogram, which procedure might cast discredit upon the art of roentgenology.

From reading these reports we can draw one important conclusion, namely, that whether the report is brief or lengthy, a standardized nomenclature should be adopted. In practically none of the reports were the descriptions based upon the relative densities observed; none following the method first brought out by Crane in 1899, or the more recent one brought to the attention of the profession by Aberu of France.

In reading over the reports giving the results of the examinations of the mastoid, we were impressed by their greater uniformity, the majority of them following the type of reports in Law's work. In this particular instance, the greatest value has resulted from an authoritative and comprehensive study of a single subject.

Reports which were presented upon the work of paranasal sinuses showed great variation. Most of them were characterized by extreme brevity as to conclusions, which we might call the intuitional type. It seems to the writer that, as regards the important topic of standardization of reports, discussions and difficulties are always encountered. Very probably the solution of the problems is not to be found in reports of committees, but can be reached only by improving the methods of education along roentgenological lines, presenting to the Association of American Colleges the necessity of high standards of laboratory courses.

If we grant, then, that an attempt should be made to standardize roentgen-ray reports in standardized hospitals, the first procedure is to adopt or recommend a standardized nomenclature. As an example of this standardized nomenclature in the description of fractures, I would submit the following scheme which was sent in by Dr. Harold J. Pierce of Terre Haute, Ind.:

FORM OF REPORT ON FRACTURES

*X*-ray examination reveals
- Simple
  - *a* Complete
  - *b* Incomplete
  - *c* Comminuted
  - *d* Fissure
- Multiple
  - *e* Depressed
  - *f* Perforated
  - *g* Diastatic
  - *h* Impacted

Fracture of the
- Side
- Part

Line of fracture is
- *a* Irregular
- *b* Transverse
- *c* Longitudinal
- *d* Oblique
- *e* Spiral
- *f* T-shaped
- *g* Stellate

From a point cm. from a bony landmark
- *a* Downward
- *b* Outward (to about cm. from bony landmark)
- *c* Upward

The fragments are
- *a* In good alinement (to the extent of cm.; to the extent of degrees)
- *b* Overlapping
- *c* Angulated

The upper fragment is displaced
- *a* Upward
- *b* Downward
- *c* Inward
- *d* Outward

The lower fragment is displaced
- *a* Upward
- *b* Downward
- *c* Inward
- *d* Outward

One of the functions of the American Roentgen Ray Society is to study the question of standardized nomenclature, and to make recommendations which can be used in standardized hospitals. We feel that the Society, after recommending such a standardized nomenclature, should take steps further and recommend certain requirements which should be followed in writing roentgen-ray reports in standardized hospitals. Such a standardized procedure has been laid down for the systematizing of diagnoses, and certain standardized methods of history-taking have been adopted in many hospitals. These recommendations should suggest the form to be followed in describing lesions both fluoroscopically and roentgenographically. Recommendations along this line should not err on the side of verbosity but should outline

proper guidance, and encourage conciseness and clearness.

Another way in which the American Roentgen Ray Society could further the movement toward improvement of our roentgen-ray reports would be to require of the applicants for membership that each submit a certain number of reports which should follow a prescribed form. This is not an Utopian idea, but simply follows the example of the American College of Surgeons in the examination of their candidates.

CONCLUSIONS

1. The American Roentgen Ray Society should make an effort to secure more uniform and better roentgenological courses in the medical colleges of the United States.

2. The American Roentgen Ray Society should recommend a standardized nomenclature to be used in writing roentgenological reports.

3. The American Roentgen Ray Society should foster a standardized type of roentgen-ray reports in the examination of different parts of the body for definite conditions.

4. The American Roentgen Ray Society should require of its candidates the submitting of one hundred roentgenological reports of actual cases written in conformity with the standardized nomenclature and recommended standardized form.

# ROENTGENOLOGY AND INTERNAL MEDICINE*

BY LEWELLYS F. BARKER, M.D.

BALTIMORE, MARYLAND

INTERNAL medicine and roentgenology are closely akin. The internist specializes in the diagnosis and therapy of the so-called internal diseases, making use of every method and every principle that can aid him in this task. The roentgenologist is the master of the technique of a particular method of examination, which has become as indispensable to the physician as it is to the surgeon and to every medical and surgical specialist. In addition to command of a special technique, the true roentgenologist, in contrast with the mere roentgenological technician, is a consultant who interprets what he sees at roentgenoscopic examinations and on inspection of roentgenograms. He supplies a group of facts obtainable by the application of his methods and in no other way, facts that are often of very great importance among the totality of data upon which modern, comprehensive and exact diagnoses are based; and in the execution of the therapy based upon these comprehensive diagnoses the roentgenologist may also be called upon in turn, to play an important part.

Just as the internist must possess a knowledge of the anatomy, the physiology and the pathology of every part of the human organism and be acquainted with the practical technical methods of special workers who study each of these parts, so the roentgenologist who makes himself responsible for the interpretation of the shadow pictures obtainable from all parts of the body by *x*-ray methods, must be similarly informed with regard to the normal structure and normal functions of these parts, and with the alterations that the structures and functions undergo in disease.

A skilful technician without medical education may, it is true, after long practice under instruction, be able to make very good *x*-ray plates or *x*-ray films of the various parts of the body, but only an educated physician who has a wide and deep acquaintance with the methods and principles of both the preclinical and clinical sciences can make roentgenoscopic examinations that will be of value, or can interpret adequately the meanings of the variations in density that are visible in

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roentgenograms. No wonder, then, that the internist and the roentgenologist are reciprocally interested in one another's work, for each can receive help from, and give help to, the other. Each is a draughthorse in the modern diagnostic team. Though a large set of persons, medical, surgical and special, may be harnessed together in the work of present-day diagnosis, it will be generally acknowledged that in this set the internist and the roentgenologist must always draw the heavier parts of the load.

As a working internist who has a keen appreciation of the burden that the modern roentgenologist must bear, I desire, on behalf of my colleagues in internal medicine, to express to the members of this society our deep feeling of gratitude for the hearty support and the close cooperation of roentgenologists in our work. I, personally, owe a debt that I can never repay to my colleagues, Dr. F. H. Baetjer, Dr. C. A. Waters and Dr. Pierson, in the *x*-ray department of the Johns Hopkins Hospital. Their help in the hospital work during my incumbency and also in private practice has been incalculable. I know, too, that the internists of different parts of this country who enjoy similar relationships with roentgenologists feel just as I do. Let us who are internists reciprocate in any way that we can. It is a duty we owe you and one that we perform with pleasure, though despite our best efforts there will always be, I fear, a debit balance in your favor.

In the brief time allotted to this address I cannot do better, perhaps, than to refer to some of the ways in which the roentgenologist today is helpful to the internist and to some of the limitations to which his efforts seem to me to be subject. The field of application of roentgenology to internal medicine is so very large that I must content myself with a mere sketch, rather than try to depict any detailed picture. A talk is always more interesting, too, if it has its origin in personal experience. What I shall have to say, therefore, will be based in large part, if not wholly, upon the ways in which roentgenoscopy and roentgenography have helped me in my own diagnostic work, upon some of the instances in which I have found it misleading, and upon my own studies of the bibliography of the subject.

In making general diagnostic surveys, the consulting internist accumulates data through the anamnesis, the general physical examination, variou slaboratory tests, various *x*-ray tests and examinations made in many special domains. He secures information in these various ways regarding the respiratory apparatus, the circulatory apparatus, the blood, the digestive apparatus, the urogenital apparatus, the locomotor system, the nervous system, the endocrine glands and the metabolic processes. He then arranges the facts he has collected in groups and broods over them in order that suggestions of solution of his diagnostic problems may occur to his mind.

He reasons out the bearing of each possible suggestion of solution, compares the implications deduced with the data actually accumulated in the given case, and finally establishes identity between the facts of the case and the facts that should be demonstrable if one of the suggested solutions were correct, thus arriving at his diagnosis. He is careful not to make a diagnosis upon the anamnesis alone, upon the general physical examination alone, upon laboratory tests alone, upon *x*-ray reports alone, or upon the reports of specialists by themselves. On the contrary, he keeps his mind open, suspending judgment until he has at his disposal facts of different kinds in sufficient number clearly to define and to localize his dianostic problem.

He makes his study complete enough to prevent anything of importance being overlooked; and he tries to synthesize his total findings into satisfactory conclusions adequate to the requirements of the case. The anamnesis is exceedingly valuable to him, the physical examination is indispensable, the laboratory and *x*-ray tests may be most helpful, and the reports of experts in special domains may throw light upon obscure parts of the problem, but he depends, as I have said, upon the results of no one of these alone.

He makes use of them all in as far as is necessary for the satisfactory completion of his diagnostic task. The internist feels

that in this way, and in this way only, can patients be given the full advantages of the application of the scientific medicine of to-day.

In his work of analysis, then, the internist is greatly helped by the roentgenologist, and in his work of synthesis, or integration, the results of the roentgenological findings are given their due place and proportion. You will readily understand that an internist, working in the way I have described, will be most helped by a roentgenologist who reports both his objective findings and his opinions regarding the meaning of those findings; these two things—(1) objective description of findings and (2) interpretation of findings—should, however, be kept sharply separated from one another.

Some roentgenologists give only objective findings without interpretations; others give only interpretations without reports of objective findings. Neither of these methods of reporting is wholly satisfactory to the higher type of internist, who desires both. Moreover, the roentgenologist who reports both and the internist who receives and studies both and who under the guidance of the expert inspects the roentgenograms himself will grow in knowledge and in diagnostic ability more rapidly than when the roentgenologist restricts his reports to one or the other content.

Much is to be gained, too, from roentgenological reports that are made first without knowledge on the part of the roentgenologist of the symptomatology and secondly, later, with knowledge of that symptomatology and of the other facts collected by the internist. It is helpful both to the roentgenologist and to the internist to see how far the former may go from the application of his own method and technique alone. Subsequent to this, much is to be gained from a conference of the internist with the roentgenologist at which all the clinical and laboratory findings are considered in association with the *x*-ray findings. This plan, though time-consuming, makes for the progress of both roentgenology and internal medicine, especially if both roentgenologist and internist later on control their conclusions (1) by the subsequent clinical course, (2) by any surgical operations that are performed, and (3) by autopsy findings in fatal cases.

### RESPIRATORY APPARATUS

No better example of the successes of *x*-ray examinations on the one hand and of the limits of their performance on the other could be given, perhaps, than the results obtainable in the study of diseases of the respiratory apparatus.

No internist to-day would be willing to try to get along without the information that the *x*-ray can give concerning the lungs, the pleura, the air passages, and the lymph structures and the blood vessels of the respiratory organs.

*X*-rays of the paranasal sinuses and of the chest have become almost routine in the study of clinical cases. The specialist on diseases of the nose and throat would scarcely venture an opinion in his domain before ascertaining the condition of the antra, the frontal sinuses, the ethmoid cells and the sphenoidal sinus as revealed in roentgenograms. For roentgenography gives information that is more reliable than transillumination of the sinuses can yield.

The internist desires to compare the physical findings of the lungs and pleura with the findings in the *x*-ray plates, especially if he suspect a dilatation or a stenosis of the air passages, a foreign body in the bronchi, or an inflammatory or neoplastic process in the lungs or pleura. If gangrene of the lungs, abscess of the lungs, or empyema be suspected, he desires to confirm his physical findings by *x*-ray examinations and, especially if operation be indicated, to determine the exact position, the form and the extent of an inflammatory focus or of a cavity. He wants to be sure, too, whether a process is single or multiple and, if multiple, whether operation offers chances of success. In lung abscesses, the demonstration of a 'fluid level' with a clear space above due to air in the abscess cavity, and a comparison of the appearances in roentgenograms taken in the upright with those taken in the recumbent position are important aids to clinical diagnosis.

In pulmonary tuberculosis, the *x*-ray is less helpful in deciding that tuberculosis exists than in giving definite ideas as to the exact location and extent of a process known to exist. The *x*-ray demonstrates the precise anatomical relations of tuberculous foci, but it will not always determine how much of a process is tuberculous and how much is due to a complicating bronchopneumonia, due, say, to streptococci. Moreover, reports regarding activity or inactivity of a tuberculous process based upon *x*-ray findings alone are peculiarly dangerous and inaccurate. Much more, in my opinion, can be decided regarding activity and prognosis by methods other than the *x*-ray. Roentgenologists have been responsible too often for sending persons to sanitaria when they did not need to go; many people have been compelled to give up their work and go to the Adirondacks, to Asheville, or to Arizona, at great expense and on insufficient grounds. On the other hand, the roentgenologist will sometimes make a negative report on the lungs of a patient who has incipient tuberculosis and whose sputum contains tubercle bacilli. His report may be entirely correct in such a case from the *x*-ray standpoint. We must not expect roentgenograms to tell us more than they are capable of. But neither can we afford in pulmonary tuberculosis to do without the information that the roentgenogram can yield. I have been more than once genuinely astonished to find how wide-spread the anatomical changes demonstrable by the *x*-ray were in tuberculous lungs in which from the history and the physical examination I had supposed a much more circumscribed process to exist.

There are certain special circumstances in which roentgenograms contribute valuable information in the tuberculous. Thus the *x*-ray is often helpful in revealing the enlarged paratracheal glands in the tuberculosis of childhood, the areas of consolidation in tuberculosis of the senile, and the distribution of peribronchitic tuberculosis and of miliary tubercles at any age. It must not be forgotten, however, that not everything that looks like a miliary tubercle in the lungs is really due to tuberculosis. Great conservatism should be observed in drawing etiological conclusions from roentgenographic shadows. More than once roentgenologists have made the diagnosis of acute, or subacute, disseminated miliary tuberculosis, when in reality they were dealing with non-tuberculous lesions. Dr. George Dock of St. Louis has dwelt upon some of the fallacies to which the roentgenologist of the chest is liable, in an admirable address that he delivered last June, and which was published in THE AMERICAN JOURNAL OF ROENTGENOLOGY.

In the diagnosis of tumors of the lung, internists have been greatly helped by the *x*-ray, especially when recurring small hemorrhages of the lung otherwise unexplained have occurred in men or women past middle life. Such tumors may be primary, originating either within the bronchus of a lung lobe or at the hilus, or secondary metastatic growths often visible in both lungs. But here, too, roentgenograms are not always decisive, for it may be difficult to distinguish the shadow of a primary tumor of a lobe from that, for example, of a pneumonic consolidation; and it is especially hazardous to be dogmatic regarding the existence of a carcinoma of the hilus, which can so easily be confused with tuberculous or luetic changes there. Miliary carcinosis has been mistaken for miliary tuberculosis, for pneumonoconiosis, and for other minute disseminated lesions. When there is thickening of the pleura or a pleural exudate over a lung tumor it may be difficult to recognize the latter. Even the differential diagnosis between tumor and aneurism is not always easy.

Roentgenograms are very helpful in the exact delimitation of pleural thickening, in the determination of the extent of a pleural exudate, in the recognition of interlobar exudates and thickenings, and in the discovery of pneumothorax.

In mediastinal disease, roentgenograms are very useful in determining the size of, position of, and presence or absence of pulsation in space-occupying masses there, and often clues as to their nature can thus be obtained. The enlarged lymph-glands of Hodgkin's disease and other masses in the mediastinum often show rather char-

acteristic shadows, but one usually has to depend upon methods of examination other than the *x*-ray for a decision as to the real nature of such masses. Dermoid cysts are rare, but are often recognizable in the *x*-ray when they are present. A substernal struma can sometimes be recognized by its triangular shadow with the base upwards, especially if a connection with a goiter in the neck can be established; care must be taken, however, not to confuse such a substernal struma with an aneurism of the arch of the aorta.

A word as to enlarged thymus. Where an enlarged thymus has been suspected, my experience with *x*-ray reports has been rather disappointing; either no shadow has been found at all, or a thymus shadow has been confused with shadows due to other masses (substernal struma, enlarged lymph-glands, mediastinal tumor, or the vena cava). Reports in the literature indicate that shadows diagnosed enlarged thymus have often failed of confirmation at autopsy.

### CIRCULATORY APPARATUS

One of the triumphs of the *x*-ray consists in the easy diagnosis of aortic aneurism when it is present, by means of roentgenoscopic examination and of roentgenograms. Indeed, the ease of diagnosis by means of *x*-ray examinations is so marked in contrast with the difficulty sometimes experienced by the older methods of physical examination that there is some danger that students and even physicians will neglect the time-honored methods of inspection, palpation, percussion and auscultation to their great disadvantage. Aneurisms of the ascending aorta, of the arch, and of the descending aorta rarely escape detection on roentgenoscopy if use be made of oblique as well as of sagittal and frontal transillumination. Moreover, on roentgenoscopy the examiner can see the exact size, position and extent of the pulsating mass, whereas by ordinary physical methods of examination only a very vague idea of these may be obtainable.

When a roentgenoscopic examination is made as a part of the routine diagnostic procedure, it is by no means uncommon to discover an aneurism that has given rise to no clinical symptoms and has been wholly unsuspected. Imagine the chagrin of a consultant who has failed to discover such an aneurism through neglect to apply roentgenoscopy! I have had my lesson, and have, therefore, for several years past made it a practice to include careful roentgenoscopic study of the cardiovascular stripe as a part of the routine study in every patient applying for a general diagnostic survey.

I have said that it is easy in the majority of cases to make the diagnosis of aortic aneurism on careful *x*-ray examination. But, now and then, a case is met with in which the greatest difficulty is experienced and in which the most expert roentgenologist may go astray. Other processes in the mediastinum (mediastinal tumors, lymph gland masses, dermoid cysts, substernal struma, esophageal diverticula, cold abscesses, etc.) may sometimes closely resemble aneurism. I remember very well a patient I once saw with Dr. H. C. Buswell of Buffalo as a fellow consultant. Physical examination indicated the presence of a large space-occupying mass in the mediastinum, but the physical signs did not favor the view that this mass was an aneurism. I inclined to the diagnosis of a non-aneurismal mass, probably a lymphosarcoma. One of our best roentgenologists, very reliable and conservative, examined the patient roentgenoscopically and roentgenographically and, despite the clinical signs, felt sure that he was dealing with aneurism, indeed with a large aneurism of the aorta. He even went so far as to say that he would, in the case mentioned, almost stake his reputation upon the diagnosis of aneurism. Shaken by his feeling of certainty, I revised my diagnosis and reported to Dr. Buswell that I had reluctantly concluded that the patient had an aneurism. Dr. Buswell was braver than I; he had the courage of his clinical convictions and maintained that in his opinion the mass could not be aneurism. He referred the patient to Dr. Burnam for radium treatment and, to his joy and our surprise, the mass entirely disappeared!

The study of the cardiovascular stripe in general by roentgenoscopy, orthodiagraphy

and the teleroentgenogram I regard as most valuable in clinical diagnosis. Notwithstanding all the objections made, I feel that we get information regarding the size of the heart as a whole and of the great vessels, and particularly regarding the form and size of the left ventricle, the left auricle, the pulmonary artery, the aortic knuckle, and the right auricle, that can be obtained in no other way. Especially in the obese, ordinary percussion, as everyone knows, is most fallacious, and even in persons of normal weight I have seen great discrepancies among the percussion results of supposedly accurate clinical observers. The methods of percussion in common use for the demonstration of the outlines of the heart and great vessels certainly demand revision in the light of *x*-ray findings. Time will not permit me to dwell upon the details, but the information that can be gained by a careful study of the configuration of the heart silhouette obtained by the *x*-ray is now much relied upon by internists for confirmation and extension of the findings on physical examination in valvular diseases of the heart, in hypertrophy and dilatation of the several chambers, in myocardial diseases, in congenital malformations, and in diseases of the pericardium.

### DIGESTIVE APPARATUS

The amount of time, energy and equipment expended in *x*-ray studies of the digestive apparatus exceeds, I suppose, that in any other domain. If you will recall the number of dental *x*-rays, of esophageal examinations, of roentgenoscopic examinations of the gastrointestinal tract, of plate series after contrast meals, of gall-stone plates and of barium enemata made every day, you will agree with me in this statement, I feel sure.

Dental roentgenograms have revolutionized both medical and dental practice in recent years. Internists, in their search for focal infections, have discovered the importance of oral sepsis for the origin of lesions at a distance (antritis, endocarditis, arthritis, myositis, nephritis, etc.); and dentists have begun to realize that the frivolous devitalization of teeth formerly resorted to in connection with their beautiful crown and bridge work led often to disastrous results later on. You are all familiar with the remarkable conditions that have prevailed in this country during the past few years. I need not recount them. Nor need I dwell upon the many tragedies of unnecessary wholesale tooth extraction that we have all witnessed. Dentists, physicians, and even the laity, however, are becoming better informed regarding the situation, and dentists and physicians are now happily tending ever more to desirable collaboration in the study and treatment of patients. From now on, a tooth, let us hope, will never be unnecessarily devitalized, nor should a tooth be extracted unless it is really a menace to the person who carries it. The *x*-ray, here, can be a blessing or a curse, according to the way in which its findings are interpreted and acted upon.

The diagnosis of esophageal diseases has been rendered infinitely more satisfactory through the use of *x*-ray methods of examination. Through their application, diverticula, stenoses, tumors, idiopathic dilatations and the presence and situation of foreign bodies are, as you know, now easily recognizable.

It is, however, in the study of the stomach, the duodenum and the large intestine that the greatest advances, perhaps, in the domain of the digestive apparatus have been scored. Our knowledge of the form relations of these structures in the living, of the tonus, and of the peristalsis, in health and disease, has been greatly forwarded through the application of the *x*-ray. When one thinks of our ignorance of gastrointestinal function at the end of the last century and compares it with our present knowledge he cannot but be most grateful to roentgenology.

I could spend the whole evening in discussing the information that the *x*-ray can give us regarding the structure and functions of the digestive tract, and another evening in a critical examination of the deficiencies of the method. I shall, however, refer only to gastric and duodenal ulcer, to cancer of the stomach and of the colon, to diverticulitis, to the gall-

bladder and to the appendix, and shall make only brief mention of these.

That through the *x*-ray extraordinary advances have been made in the more precise diagnosis of ulcer of the stomach and of the duodenum everyone knows; but that, even here, *x*-ray reports often fail us, every internist who sees many gastric cases also knows. American roentgenologists have made important contributions to the technique of the demonstration of ulcer signs. When an ulcer has been chronic and has led to cavity formation with thickened walls, the *x*-ray often reveals a typical ulcer crater or niche; but the *x*-ray diagnosis of ulcer depends in many cases not upon the discovery of direct ulcer signs but upon the discovery and interpretation of certain indirect signs in the form of functional disturbances. For gastric ulcer these include local spasms, incisures on the greater curvature, changes in peristalsis and in emptying time, signs of hypersecretion, localizable pain points on roentgenoscopic examination, and for duodenal ulcer they include spasm of the bulb, permanent filling of the pars superior, displacement of pylorus to the right, shortened emptying time of the stomach, reflex gastrospasm, and other signs of disturbed function. Sometimes the *x*-ray may give information regarding certain sequels of an ulcer (hour-glass stomach, perigastric adhesions, gastrectasia from pyloric stenosis, etc.). When there are no direct ulcer signs present, roentgenologists should, I think, be very conservative in making a positive diagnosis from the functional symptoms alone or from the supposed anatomical sequels alone; for similar functional symptoms may appear in association with nervous gastropathies, or reflexly from gall-bladder disease, or from a chronic appendix, and similar anatomical sequels may follow upon pathological peritoneal processes not secondary to ulcer.

Again, the differential diagnosis between ulcer of the stomach and ulcer of the duodenum or a decision as to the presence or absence of ulcer in either stomach or duodenum may, in some cases, be particularly difficult, especially in the absence of an exact anamnesis and of carefully conducted laboratory tests. On the functional side it is true that marked hypermotility visible on *x*-ray examination and spasm of the stomach without niche suggest ulcer if the rest of the gastrointestinal tract be negative and if there be no tuberculosis of the lungs and no marked neurotic state. When *x*-ray functional signs of ulcer are present, a slow emptying time speaks in favor of pyloric ulcer, a rapid emptying time in favor of duodenal ulcer. Surgeons, of course, went too far a few years ago in declaring that marked hyperacidity always means ulcer. Roentgenologists have sometimes gone too far in ruling out ulcer from their own findings when the clinical findings (typical pains, marked hyperacidity, hematemesis, occult blood in stool, etc.) have been positive. When all diagnostic methods are used, it seems clear that there are a certain number of cases in which the internist is justified in deciding that ulcer is certainly present, or at least highly probable, even though the *x*-ray findings are negative, or are very uncertain.

In cancer of the stomach we can count upon the *x*-ray to give us important information. It frequently reveals tumor masses, or evidence therefor, before they are palpable and even at a stage when the chemistry and microscopy of the gastric contents may not be decisive. It distinguishes extra-gastric from intra-gastric masses; it permits of a determination of the exact location and size of the tumor; it often demonstrates the presence or absence of metastases in the lungs or in the bones; and it may give clues to operability and to the best surgical technique to employ. In cancer, there may be demonstrable certain characteristic filling defects (constant, not removable by palpation or change of position); the gastric peristaltic waves may be seen to be interrupted at a definite point; and if the pylorus be not obstructed, emptying time may be shortened owing to the accompanying achylia. In cases of pyloric obstruction, marked dilatation favors the diagnosis of cancer, moderate dilatation that of ulcer. In some cases it may be impossible from the *x*-ray findings alone to decide between benign ulcer and cancer.

Now and then a patient who has not complained of gastric symptoms at all will be found to exhibit, on roentgenoscopic examination, signs of a huge gastric cancer. For this reason, I ask for a roentgenoscopic examination of the gastrointestinal tract as a routine measure in general diagnostic surveys, for the consultant cannot afford to overlook a symptomless gastric cancer any more than he can afford to overlook a symptomless aortic aneurism.

On the other hand, I have at times received negative *x*-ray reports when gastric cancer existed. I remember last autumn a physician from the south who consulted me on account of a severe anemia, which proved to be of the secondary type. There was also achylia gastrica and he had occult blood in the stool. No tumor mass was palpable anywhere. We suspected, of course, carcinoma of the stomach, or possibly an old ulcer with recurring small hemorrhages. Repeated *x*-ray examinations, however, revealed no signs either of ulcer or of cancer. Blood transfusions gave only temporary help, and the stools continued to contain small amounts of blood. Dr. John Dorsey, the resident physician in charge of the private ward, urged the importance of the persistence of the blood in the stool and I advised the patient to submit to exploratory laparotomy. He consented to this and Dr. Finney exploring found a carcinoma of considerable size on the lesser curvature of the stomach. The *x*-ray plates were reviewed after the operation but the roentgenologist, an expert, reported that, even knowing that a cancer was present, there was nothing to be seen in the *x*-ray plates to indicate it, nor had anything been observed on roentgenoscopic examination pointing to it.

In the study of gall-bladder disease we have been helped much less by the *x*-ray than in the study of ulcer or cancer of the stomach. Though it is true that, in 10 or 15 per cent of the cases, gall-stones if present will appear in the plates with ordinary technique and that, in a much larger percentage of cases, their presence can be demonstrated if rays of low penetrating power, duplitized films and special screens be employed, still we know that gall-stones are present in many cases in which the *x*-ray findings are entirely negative. Similarly, the *x*-ray is powerless to demonstrate the presence or absence of a cholecystitis, unless there be pericholecystitic adhesions or marked dilatation of the gall-bladder and, even then, the findings are often equivocal. Again, many of the shadows in *x*-ray plates reported as gall-stones have been shown not to be gall-stones at all, but other shadows in the neighborhood (e.g., calcified costal cartilages), though the roentgenologist can, as a rule, by making examinations at different phases of respiration and in different positions distinguish gall-stone shadows from simulants. In my experience, for the diagnosis of cholelithiasis, cholecystitis, biliary stasis, etc., the general clinical study (anamnesis, physical examination, laboratory tests) has been much more helpful (except in the few cases in which stones are actually visible) than the roentgenological findings. The help that the *x*-ray can give regarding these right upper quadrant lesions is of course not to be despised, but it should not be overestimated.

The same remark holds for the right lower quadrant—the region of the appendix and the ileo-cecal valve. An appendix should not, in my opinion, be removed simply as the result of abnormal *x*-ray findings, if the clinical study be otherwise negative. Moreover, clinical studies may not infrequently indicate the necessity for the removal of an appendix when the *x*-ray findings are negative. In doubtful cases, the *x*-ray report may be decisive if it include a curled appendix, a persistent filling of the appendix, or signs of adhesions in the right lower quadrant, such as displacement of the stomach downward and to the right and ileal stasis.

In the diagnosis of annular carcinoma of the colon and of diverticulitis, the barium enema is a great boon. Many cases of these two diseases are now recognized that formerly would have gone overlooked for a long time.

In the analysis of cases of chronic constipation, *x*-ray studies are also very helpful. The separability of the ascendens type with its marked cecal stasis, the determinability of the markedly spastic

type with mucous colitis, and the recognizability of the *x*-ray appearances in dyschezia are some of the interesting achievements.

The peculiar filling defects met with in ileo-caecal tuberculosis and in carcinoma of the caecum are exceedingly helpful diagnostic signs. That, also, an unsuspected Hirschprung's disease will occasionally be revealed by a routine *x*-ray study is matter of common knowledge.

In how far the recently introduced method of artificial pneumoperitoneum will prove to be justifiable and helpful, it is as yet too early to say. Certainly, masses in the abdomen that cannot be shown in any other way can be revealed by this method. Still, one would like to feel sure, in a given case, that the results to the patient would compensate him for the discomfort he has to undergo and for the risks of air embolism and of infection that he runs, though these risks seem to be slight.

### UROGENITAL SYSTEM

The internist, as well as the urogenital specialist, owes much to roentgenology for the help that it yields in diagnosis in urogenital domains. Its successes are most clearly seen perhaps in the demonstration of the presence (and the determination of their size and exact location)of stones in the kidney, in the renal pelvis, in the ureter, in the bladder and even in the prostate, especially in the lateral regions of the prostate where they may be inaccessible to palpation.

Pyelography, with the aid of collargol or of thorium nitrate, is now indispensable in cases in which it is necessary to determine the shape and position of the kidneys, of the renal pelvis or of the ureters. Plosis of a kidney, and dilatations, stenoses and kinks of the ureters, can be very clearly shown. A diverticulum of the bladder, or a bladder tumor, can sometimes be discovered by cystoro entgenography after injection of a 10 per cent solution of potassium iodide in cases in which cystoscopy, for one reason or another, cannot be applied.

Though roentgenography, as I have said, is a most reliable method for the demonstration of the presence or absence of stones in the urogenital organs, it does fail in a certain percentage of the cases. Thus stones have been shown to exist when the *x*-ray plates were negative and, on the other hand, shadows have been interpreted as renal stones or ureteral stones when they were due to gall-stone shadows, to calcified costal cartilages, to calcified glands, to scybalae, to phleboliths or to bones or teeth in dermoid cysts. The roentgenologist who tries to interpret plates of the urogenital domain should be familiar with all these possibilities and should give them due consideration when making a differential diagnosis.

Even the ejaculatory duct and several inches of the vas deferens can now be injected with a shadow-yielding fluid, a method that may prove to be of practical use to urogenital specialists.

In carcinoma of the prostate, operation should not be undertaken until after *x*-ray examinations of the bones and of the lungs have been made for metastases. The same is true in carcinoma of the kidney and in hypernephroma.

### LOCOMOTOR SYSTEM

In the study of the locomotor system, *x*-ray help is precious, though the surgeon and the orthopedist are more intimately concerned, perhaps, than the internist. Still, the internist also has to study diseases of the bones, joints and muscles, and, in his study, he desires the aid of the *x*-ray findings. They throw much light upon the nature and the extent of the arthropathies, the osteopathies and the myopathies. In arthritis, the *x*-ray will determine in how far the process has involved the solid parts and the soft parts of the joint structures and gives clues to the stage of the process, the kind of the process, and prognosis. *X*-rays of the spine often reveal the cause of lumbago, sciatica and of girdle pains in the trunk (arthritis, tumors, sacralized fifth lumbar vertebra, osteomalacia, etc.). The demonstration of the presence of cervical ribs will often clear up the etiology of severe radiating pains in the arms. Osteomyelitis, tuberculosis of bones, luetic periostitis, and neoplastic changes in the bones, are, as a rule, easily recognizable in the *x*-ray.

The changes in osteogenesis imperfecta and in osteomalacia are characteristic. Only last week a patient consulted me complaining of vague pains throughout the body, especially on movement. She stated that she thought she was growing a little shorter in stature. On *x*-ray examination of the spine, osteomalacic softening of four of her vertebrae was discovered, the roentgenologist solving at a stroke the diagnostic puzzle.

Finally, the internist remembers gratefully the significance of symmetrical bone defects at the edges of joints for the diagnosis of gout, and of smaller and larger circumscribed spherical bone defects for the diagnosis of multiple myeloma, even when Bence-Jones body is not present in the urine.

### NERVOUS SYSTEM

Abnormal masses within the nerve substance are rarely demonstrable directly except when calcification has occurred (in tumors, solitary tubercles, gummata, cysticercal cysts, old inflammatory foci, etc.). Calcifications of the pineal body, of the choroid plexus and of pacchionian granulations are easily recognizable.

Recently, through Dandy's brilliant studies with the help of roentgenologists, it has become possible, in many cases, to localize non-calcified tumors of the brain by means of ventriculo-roentgenography (air injection of the cerebral ventricles). The technique is not difficult, and though there is some danger incurred, it is minimal, and the successes achieved in the localization of non-focal tumors of the brain before operation thoroughly justify the procedure in selected cases.

Local and general pressure effects within the skull revealed by the *x*-ray are often helpful in differential diagnosis. Changes in the sella turcica have been much studied with relation to intra-sellar tumors and extra-sellar tumors, in acromegaly and in dystrophia adiposo genitalis; but it should be remembered that the form of the sella is often changed from a general increase in intracranial pressure due to causes far removed from the hypophysis, and that it may be changed, also, by alterations in the sphenoidal sinus underlying the sella.

Diffuse pressure effects within the skull are evidenced by a marked increase in the digital depressions visible in the *x* ray and in the sharpening of the ridges between them. Premature closing of the cranial sutures in the craniostenosis of the tower skull is a characteristic roentgenological finding.

Much to the disappointment of the laity and of many physicians, the changes in the brain and skull in epilepsy demonstrable by the *x*-ray are rarely of much help to the diagnostician. The finding of a small, closed-in sella in epilepsy is, in my opinion, of no practical importance. Sometimes we see irregular deformations of the skull, sometimes a foreign body, sometimes signs of increased intracranial pressure, or occasionally calcified residues of old inflammatory foci; but, in the majority of instances, *x*-ray findings in epilepsy have been practically negative.

Roentgenology is also applicable to a certain extent in the study of diseases of the spinal cord and of the peripheral nerves. In organic diseases of the spinal cord, the *x*-ray may be helpful in diagnosis (Charcot's joint in tabes, bone changes in syringomyelia, vertebral caries in compression myelitis). Spina bifida is easily revealed by the *x*-ray and may account for obscure organic nerve lesions. Cervical ribs as causes of neuralgias in the domain of the brachial plexus have already been referred to. Paralysis of the nervus recurrens in aneurysm, root pains in hypertrophic osteoarthritis of the spine, paralysis of the diaphragm due to lesions of the N. phrenicus, intermittent claudication in arteriosclerosis, and paralysis of the cervical sympathetic in retrosternal struma are among the objective and subjective clinical findings that are often explicable by a study of roentgenograms or by roentgenoscopy.

### ENDOCRINE SYSTEM

In certain endocrine disorders, finally, the *x*-ray findings are helpful for diagnosis. I may mention, without describing them, the bone changes in acromegaly and in dystrophia adiposo genitalis where the pituitary gland is diseased, the finding of a substernal thyroid in some cases of

Graves' disease, the occasional demonstrability of an enlarged thymus in status thymicolymphaticus, especially in children, the premature union of the epiphyses with the diaphyses in dwarfism due to hypergenitalism, the delayed union of the epiphyses in hypogenitalism, and the delayed ossification and the anomalies of dentition in the hypothyroidism of myxedema and cretinism.

## CONCLUSION

In this address I have been able only to touch upon the most salient features of the advantages of roentgenology for internal medicine and to refer to a few of its difficulties and dangers; but I have said enough, I trust, to convince you that those of us who work in internal medicine appreciate highly the gifts of which the roentgenologist can be donor, and that we observe with sympathy and gratitude the efforts of the members of this association to make roentgenology ever more useful to us.

It is especially pleasing to internists to note that the tendency among roentgenologists to make more intensive and specialized studies than formerly is growing. There is great need for original research in roentgenology, research directed not only toward the improvement of technique but toward the more accurate interpretation of findings through control by clinical studies, through observation of the findings at the operating table and through checks upon intra vitam interpretations made after exact anatomical examinations at autopsy.

In our larger cities it would be advantageous if roentgenologists would unite into groups, so that specialization within the groups would become possible, each specialist being responsible, not only for routine studies in his particular domain, but also for the prosecution of original research in that domain. It would be especially helpful if our large hospitals and our universities would provide the funds for such amplification and intensification of roentgenological work. Too often the most meagre budget is appropriated for the *x*-ray departments in these institutions, the niggardly amount placed at the disposal of *x*-ray workers being really insufficient for the carrying on even of careful routine examinations. Nothing is left over for research work and we have to thank the roentgenologists themselves for defraying the expense of their productive studies. I am told that in some hospitals and medical schools, the *x*-ray departments are not only required to make enough money to pay the expenses of the *x*-ray work, but are expected also to provide a surplus for the use of other departments! I have the hope that hospital superintendents and medical faculties may, before long, become wise enough to recognize the crying needs of roentgenology, and energetic enough to secure the funds adequately to provide for them.

Let me, in closing, assure you that you will among the internists in this country find enthusiastic allies in your struggle to attain your ideals. Everything that contributes to your advance and to the advance of the subject you represent will also help internists in their work of diagnosis and treatment.

## DISCUSSION

DR. HICKEY. I would like to say we have experienced much pleasure in hearing this masterly résumé of the work which has been done in roentgenology. Those of us engaged in teaching will, I am sure, use this résumé and try to outline the topics which can be covered in the subjects discussed. It is very gratifying to help the spirit of cooperation which we think can be established between the roentgenologist and those interested in medicine. It was delightful also to hear Professor Barker speak of the passing of the tendency of the internist to rely on other methods of diagnosis than those he has been accustomed to. It is deplorable that some of the younger men, as we see them in the hospitals, will not place more dependence upon the methods of diagnosis which have been given them in the older methods of examination. The best interests of the patients are not observed by such a procedure. I think the society is to be congratulated in having heard this very instructive talk. Another thing which occurs to me before closing is that some of the mistakes the roentgenologists have made have been due to their being too much crowded. The telephone rings for the diagnosis before they have really finished the last part of the routine. The

internist does not content himself with one examination. He examines the patient several times and re-examines; and I think one way to guard against some inexcusable errors is to repeat our examinations. We do not give ourselves a chance to study the cases thoroughly.

Dr. Moore. I wish to thank Dr. Barker for the manner in which he has brought out this subject. It seems that if we are fortunate enough to be so located, that after drawing our opinions from our signs we can submit them to some consultant who will help us, we can finally place our specialty at the top—where we wish it to be. I could not help but be impressed by what he said. If we will be positive in so far as opinion justifies us in presenting the evidence we collect from direct signs, and then present the evidence collected by indirect signs with realization of the limitations, we will be in some degree such a help to the internist as he is to us.

Dr. Christie. It has been very pleasing indeed to hear Dr. Barker's appreciation of the roentgenologist and to hear his criticisms. I suppose perhaps each of us is struck with a different thought in regard to it. One of the things impressing me is that not only must the roentgenologist realize his limitations, but it is important for the internist to realize the limitations of roentgenology. It is very frequent that the roentgenologist of not too great experience is pushed off his feet by himself—he is so anxious to arrive at the positive diagnosis that he goes too far. He has come to realize the limitations as Dr. Barker has presented them. Another thing is this, that roentgenology has come to be such a broad field. We cannot be specialists along these lines, but it is necessary for the roentgenologist to meet a man on his own ground. The specialist in diseases of the chest must know his problems with sufficient assurance to talk in his own language. It seems the field is so very broad that the solution of it must come by groups of roentgenologists getting together. We have tried to divide our subjects so that each has a particular branch to follow, and I think this is the only way we can have a knowledge of such an immense field as roentgenology must cover. Another thing is this. If we are to take our places at all as consultants, and I think it is gratifying to have this word used, we want to be considered consultants—if we are to reach that ideal at all, there must be a great change in all branches of medicine toward roentgenology. We must have some method of roentgenology, and the time is ripe when we must discuss these things. I believe all of us should give it a great deal of thought from now on. We owe much to Dr. Barker for coming here and speaking in this way.

Dr. Holmes. The situation, I feel, after hearing this presentation, has been expressed very readily. There are one or two things, apparent, probably because they have entered into our own work so much. One is the necessity, as Dr. Hickey pointed out, of a careful description of things as we see them before we draw conclusions. The internists are appreciative of that fact, but they want to know on what we base our conclusions; and I think if we take more pains we will gradually get a better vocabulary than at present, so that we can express ourselves more clearly. Another thing is the tendency of medical men to obtain medical information as a fact. In some hospitals the roentgenological department comes under the laboratories. I have found that there is danger in this arrangement. We have to be very careful in making our statements; and I think if we have more instruction and if they see our work more, they will realize to a greater extent, our difficulty. Our examination of a heavy person with a high stomach is not as valuable as in cases where the stomach can be easily felt. More and better instruction will help along these lines. We are very appreciative of the help of the internists and the attitude they are taking.

Dr. Barker (closing discussion). First let me say how gratifying it is to me that my paper has called forth so much discussion—as I said when I started out, I think the discussion is really more interesting than the paper itself.

Answering the last question first: possibly I did not quite make myself clear. The speaker gathered from what I said that I referred only to the distant relations of the teeth. My intention was to mention the teeth as the first portion of the digestive tract. As a matter of fact, I believe the teeth are much more closely connected with the other organs than with the digestive tract.

Dr. Hickey spoke of the hurry of the work. This is almost a disease. We are all too hurried. You roentgenologists are too hurried. I do not know why we cannot get the leisure they have in Europe. I think those of you who have studied in Europe will appreciate all the more the fact that they lead much wider lives in certain respects, but less deep lives in other respects. Perhaps we will learn how to live over here later on.

This brings up a little incident which happened some few years ago when I was in Chicago. One of my colleagues rose at five o'clock in the morning to play golf. He

had to be at the laboratory at eight, and so in order to get in his game of golf he had to rise at five o'clock.

Dr. Hickey referred to the repetition of examinations and spoke about the internist repeating the examination of the heart. I imagine the reason the roentgenologist does not do it so often is two-fold. It is the internist's feeling that the examination is made but once; and then the expense again has something to do with each. It does not cost much to listen twice with the stethoscope.

Dr. Moore referred to the lack of interest on the part of some of the students and the internists, and I believe Dr. Bowen also referred to the fact that they are not interested. They are not of course interested in descriptions. They want to know what is what. Also the internists do not have much time and their work is heavy. How can you expect the student to be interested if he is taking courses in roentgenology and the rest of the time is under doctors who do not know the value of leisure, who do not know how to appreciate it or to make use of it where it ought to be supplied? Can you expect them to be interested?

Dr. Christie has said that the internist must realize the limitations of roentgenology. That is true. We internists are gradually learning what the *x*-ray can do. We thought it could do impossibilities. We have to learn not to make these unfair demands. The laity does not know what it can do, but the family doctor is apt to expect that the roentgenologist can do everything. We have to have general men. We also have to have the intensive specialist in each branch. I believe it is valuable for some men to be very wide and for other men to limit their work. We need both kinds of men in roentgenology just as we do in medicine. The laboratory report should be a fact and the truth, but the internist should remember it is part of the truth. I think the internists are more and more realizing the difference between the consulting roentgenologist and a picture-taker. The layman thinks the roentgenologist is a picture-taker. He wants a plate, and I hope you do not give it to him—that is not what he should have. He thinks that if he brings a plate to you and you glance at it, that is not worth anything. For the internist not to understand the difference between a photographer and a roentgenologist is inexcusable

# APPENDICITIS DUE TO THE PRESENCE OF FOREIGN BODIES IN THE LUMEN OF THE APPENDIX*

BY JOHN T. MURPHY, M.D., F.A.C.P.

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ALTHOUGH appendicitis is now recognized as a lesion of microbic origin, it is necessary to consider that in the occasional case foreign bodies may be a predisposing factor. The literature to the present time reports relatively few foreign bodies, but I think a more extensive canvass of the surgical work done and not reported would lead to the discovery of a far greater number. There are, however, several facts found in searching the literature which would lead one to believe that it still is a comparatively rare phenomenon. Kelly,[1] in 460 cases, found only one; Bell,[2] in 1,000 cases, found 5; Kelly and Hurdon,[4] in 1,000 cases in the Johns Hopkins Hospital, found only 5; Fowler[3] found foreign bodies in 5 per cent of 100 cases; Grondahl[6] found foreign bodies in 10 of 400 operated cases; Heineck[7] states that foreign bodies were found twice in 3,750 autopsies. The types of foreign bodies are many, including pins, bird shot, fish bones, seeds, calculi, hairs, etc. Of these foreign bodies the pin is the most frequently reported. Mitchell[8] in 1894 collected 33 such cases from the literature. Kelly and Hurdon[4] added 13; Fowler[3] added four which these authors omitted from their statistics, and collected 13 additional cases from the literature down to 1912, making a total of 63 cases of appendicitis due to a pin in the appendix. In the literature since then I find similar cases reported by Rivarola,[9] Reichelderfer,[10] Mahoney,[11] and Fowler[3]; a total of 67 to which I will add the following 2 cases.

CASE 1. Baby, aged seventeen months. March 29, 1919.

* Read at the Midwinter Meeting of the Central Section of the AMERICAN ROENTGEN RAY SOCIETY, Chicago, Ill., Feb. 22, 1922.

*Diagnosis.* Mass in right side. *X*-ray showed pin in region of ileocecal valve.

*Operative Diagnosis.* Abscess in ileocecal region.

*Treatment.* Incision and drainage.

*Family History.* Parents living. Negative.

*Personal History.* No previous illness.

*Present Illness.* Last June, nine months

Shadow of Pin, Case 1.

previously, baby swallowed pin. Two weeks ago began to show indications of stomach trouble. Refused food. March 27, 1919, mother noticed mass in right side of abdomen. *X*-ray showed pin in region of ileocecal valve.

*Physical Examination.* General condition fair. Mass in right side.

*At operation.* Abscess.

*Description of Operation.* Incision and drainage. Patient returned for second operation on April 12, 1919.

*Diagnosis.* Pin in intestinal tract.

*At Operation.* Pin in appendix. Perforated, small pocket of pus.

*Description of Operation.* Incision along line of old incision. Appendectomy: Iodine catgut for ligation; purse-string suture of linen; amputation. Stump treated with carbolic and alcohol; inverted. *Closure:* Iodine catgut No. 3; fascia, chromic catgut No. 2 (double). Skin, silkworm gut. Iodoform gauze drainage.

CASE II. Female, aged fifty-eight. Operation, April 25, 1919.

*Diagnosis.* Abdominal exploratory.

*Operative Diagnosis.* Inflammatory mass adherent between uterus and bladder containing appendix.

*Family History.* Mother living at seventy-five years, and well. Father died at seventy-eight. Two sisters not living: one died in childbirth; the other from an unknown cause. No record of tuberculosis or carcinoma.

*Personal History.* Record of healthy childhood and girlhood. Menstruation eighteen years, duration four days, regular. Married at nineteen. Seven children living, three dead; one died of pneumonia, one in infancy, one following childbirth. No other pregnancies. No constipation. No leukorrhea. Menopause at forty-two years.

*Present Illness.* Pain in right abdomen for eight or nine weeks. Gives record of sensation of "breaking" in abdomen seven weeks ago. Some nausea recently. No flowing or discharge. No marked loss of weight.

*Physical Examination.* Tenderness over whole lower abdomen. Bimanual examination shows thickening of broad ligament.

*Condition Found at Operation.* Inflammatory mass adherent between uterus and bladder, bound up with omentum, glands along ileum and cecum, immobilizing the cecum. Appendix in abdominal mass. Pin found which had perforated appendix and was surrounded by hard fecal matter. Different portions of mass resembled carcinoma. Mass sent to laboratory for examination.

*Description of Operation.* Median line incision. Freed mass and brought out of abdomen. In examining it found a pin which had perforated the appendix. Surrounding pin was hard fecal matter. Appendectomy. Iodine catgut No. 3 used throughout. *Closure:* Peritoneum, iodine

catgut No. 3; fascia, chromic catgut No. 3. Drainage of tube and iodoform gauze.

*Pathological Report.* Section from specimen shows chronic inflammation involving a mass of fibrous tissue and fat; possibly might be called a fibrolipoma.

Mitchell states that the appendix seems to act especially as a trap for pointed bodies and for small heavy bodies such as shot. The explanation given is that such bodies by reason of their shape and weight become more easily engaged in the appendicular orifice and fall into the canal. On the other hand, it is extremely difficult for such objects as fruit seeds to pass through the appendix lumen except when the appendix is of the fetal type. The point of a long, narrow, pointed body, such as a pin, can enter the lumen of the appendix without difficulty and the intestinal peristaltic movements push it in. Bird shot are found comparatively frequently among such appendicular foreign bodies. Kelly and Hurdon[4] collected 8 cases and in the recent literature I find such cases reported by Vander Veer,[12] Ainger,[13] Hall,[14] Spence,[15] Waller,[17] and Grondahl.[6] Waller's case was curious. A bird shot in the appendix acted as a ball-valve and prevented deflation of an enormously inflated but otherwise normal appendix. Bouvoisin and de Courmont[33] found 13 glass beads and a nail in an appendix, contained in a strangulated inguinal hernia sac. Lossen[18] and Tixier[19] report hair bristles. Foreign bodies in the appendix act in several different ways depending on their shape and size; small sharp objects by direct erosion and pressure on the mucous membrane open a means of infection into the submucosa and muscular coats; larger objects, by interfering with emptying, cause stasis in the appendix. At other times the sharp foreign bodies may cause a direct perforation with abscess formation or a general peritonitis.

Intestinal worms are frequently found in the appendix but it is doubtful whether such should come under the designation of true foreign bodies. According to von Becker[20] the oxyuris vermicularis is found in 50 per cent of all normal vermiform appendices surgically removed and in a similarly high proportion at post-mortem examinations. He thinks an etiological connection between the oxyuris and appendicitis can be excluded. Kelly and Hurdon[4] also remark that the oxyuris is sometimes found in large numbers in the normal appendix and may cause attacks of severe spasmodic pain simulating appendicitis. These parasites have been studied by Arbore-Rally[21] and by Metchnikoff[22] who find that they may also be demonstrated in acutely inflamed appendices and may have provoked the attack. Erdmann[23] in 29 cases of acute appendicitis in children found from six to thirty pin-worms in four cases. Kelly and Hurdon[4] collected nine cases of lumbricoids, eight of oxyuris and four of other parasites. Langley[24] has reported oxyuris, Marulanda[25] found the trichocephalus in sixteen of twenty operated cases of chronic appendicitis, and Russell and Bulkley[26] found it in 15 per cent of 129 appendices removed from children. The anchoring extremity of the trichocephalus causes abrasion of the mucosa which may result in infection. Although 89 of these removed appendices were gangrenous and contained pus, this condition was observed in only 4 per cent of those with the parasites.

Hogan[27] recently reported an unique case of appendicitis caused by the endamoeba hystolytica. This patient was operated upon for appendicitis, and pathological examination showed a true inflammatory condition involving the mucous and submucous coats and the presence of the endamoeba.

Appendicular calculi are but rarely reported. Rigollot-Simonnot and Saissi[29] reported a very large calculus (3 cm. × 18 mm. in size) in 1913. The patient did not show any acute crises and the chronic manifestations were not extreme. Although the case came to operation the operator doubted whether he would find an appendicitis. Blanchod[30] reported his own personal case of appendicular calculus. This case was diagnosed as appendicitis, but the symptoms were not all clear. A roentgenogram showed calculi which were thought to be ureteral, but verifying clinical ureteral symptoms were absent. The original diagnosis was therefore adhered to.

At operation two large calculi were removed from behind the cecum and a mass of adhesions. The appendix was completely gangrenous up to its cecal insertion. Roux in 1913 collected 7 cases in which a calculus was demonstrated in the appendix by roentgen-ray examination prior to operation. Most of the appendicular calculi are, however, more probably fecal concretions and probably not to be considered as true foreign bodies. Klemm,[31] who reported on 7 cases of appendicular fecal concretions, does not think that the presence of such stones causes any specific phenomena, but the course of an inflammation is much more rapid with them than in the non-calculus appendix.

Kleebat[32] thinks that with an appendicular concretion the indication for operation is given by the danger of stasis in the contracted portion of the appendix with resulting inflammation and gangrene. Kleebat also dwells upon the differential diagnosis in roentgenograms of such concretions from calculi in the ureters and calcareous deposits in the mesenteric glands, this diagnosis being dependent more particularly upon the clinical phenomena.

Concretions are also usually found existing around certain foreign bodies which have long remained in the appendix. This is especially true of pins. Of the total of 63 cases of pins in the appendix collected by Fowler, 22 were encrusted. In such cases it is often the concretion and not the pin which causes perforation of the appendix. But inflammatory changes in the appendix are the cause of the formation of the concretions, and not the result of their presence.

On the whole, it may be said that when appendicitis occurs from the presence of a foreign body in the appendix it runs a rather mild course except when the body is a sharp scrap of metal or some similar substance. In Fowler's collection of 63 cases due to pins, peritonitis was observed in only 13 and an appendicular abscess in 30.

In only a few instances has the incidence of a foreign body in the appendix been suspected before operation, especially in the case of calculi.

From this résumé of the literature, especially in connection with the success in the diagnosis of calculi in the appendix by the aid of roentgen rays, it is evident that the more general use of this means of diagnosis in abdominal work will soon increase the number of cases so diagnosed, both in the calcareous conditions and in other types of dense foreign bodies.

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## DISCUSSION

Dr. Kessler. I desire to report one case which occurred in the practice of one of our St. Louis surgeons, in which the symptoms

were those of appendicitis. At operation a stone was found in the appendix.

DR. LEWALD. I have a case of pin necrosis that has been present for fifteen years. The interesting point about it is that there was a sinus which finally healed and then broke down again. This sinus was in the right inguinal region. It was only after the second sinus appeared that a roentgen-ray examination was made and the presence of the pin demonstrated in the right side. The case was operated on and the pin removed. There was a little stump of an appendix in a more or less inflammatory exudate. I have a similar case which I shall investigate. I regard it as a concretion case.

Another case was of considerable interest because we were asked to *x*-ray the lung only because it was thought there was a pneumonia which was simulating appendicitis. Due to our habit of using large plates, we were able to see the condition in the appendix with a negative lung. The appendix was removed and was found to contain a pebble. Further inquiry by the attending physician led to the discovery that a week previously the youngster had swallowed a pebble.

We have 2 cases of shot similar to those Dr. Murphy has mentioned. One was found in a hernial sac; the appendix was found in the hernial sac and probably the patient was suffering more from the shot in the appendix than from the hernia. Amputating the appendix cured him. Another case occurred in a man from the south who was in the habit of eating pheasant every Sunday morning. Six shot were found in his appendix. He still has them and without discomfort.

We had 3 cases of concretions such as Dr. Murphy mentioned. One of them was almost operated on as a ureteral calculus. We catheterized the patient, made a roentgenogram and found that the shadow was outside the ureter. At operation the calculus was found in the appendix. We had 2 other cases in which large concretions had formed in the region of the appendix because they were larger than the lumen of the appendix would hold.

It seems to me that once these concretions are discovered, and if the patient is suffering from abdominal distress, we are justified in the opinion that the appendix should be removed. I am cautious in this matter, unless the clinical evidence is sufficient to warrant a diagnosis.

DR. MURPHY (closing discussion). I have nothing to add except that I think we should keep looking for these things, for in that way we may be able to clear up a case that we would not otherwise discover.

# SOME PRACTICAL RESULTS WITH A POTTER-BUCKY DIAPHRAGM*

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AT THE recent meeting of this society in Washington, a report was presented of an investigation of the efficiency of the Bucky diaphragm principle, in which a study was made of the effects of various factors in the design of the diaphragm grid. Using a container of water as the scattering material, it was found that the intensity of scattered radiation falling upon the film was determined by the ratio of the width to the depth of the diaphragm slits, and did not depend upon the absolute size of the slit or the distance between the scattering material and the film. It was found easily possible by this method to remove 80 per cent or more of the scattered radiation. The wood filler holding the lead strips in place appeared to have very little effect upon the efficiency of the diaphragm. The effect of the Bucky diaphragm upon contrast is governed by its efficiency in removing scattered radiation: its effect upon definition depends also upon the distance between the scattering material and the film; and the investigation showed that this distance had a very marked effect upon the definition. In roentgenographing through a 6 inch depth of water, with a distance of one inch between scattering material and the film, a slit ratio as small as .044 ($\frac{1}{23}$) failed to produce any improvement in definition; in

*Read at the Midwinter Meeting, Eastern Section of the AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, January 26–28, 1922.

fact the definition was poorer than without the diaphragm. However, by reducing the distance between scattering material and film to $\frac{3}{8}$ of an inch or less, with a suitable ratio of slit width to slit depth, improvement in definition was obtained in roentgenographing through 4 inches of water. In order to secure this advantage over the whole area of the film, the cassette should fit the curvature of the grid, and thus maintain the same distance between scattering material and film over all parts of the film.

These results agreed in the main with the experiments of Dr. Potter on the Bucky diaphragm, and their quantitative character made it possible to proceed with more certainty to the refinement of this most valuable apparatus. It was quite evident from this investigation that the most promising improvement of the Potter-Bucky diaphragm consisted in shortening the distance between the scattering material and the film.

For the sake of convenience, the experiments just described were performed with a single element of the Potter-Bucky grid, a single slit, whose dimensions could be varied as desired. A complete Bucky grid, whose design is based on the results of these experiments, has just been completed and it is desired to report upon the preliminary results obtained with it. The slit depth is 0.16 of an inch, the slit width 0.05 of an inch, making the slit ratio practically $\frac{1}{3}$. The lead strips are 0.010 of an inch thick; the filling material consists of strips of celluloid. The whole grid is supported in a substantial frame with a curved aluminum floor 0.02 of an inch thick. The top cover of the diaphragm is of aluminum $\frac{1}{32}$ of an inch thick, and the top of the curved cassette is of the same thickness. The free space that must be allowed between the grid and the cassette and between the grid and the diaphragm cover depends on how accurately the curved surfaces approximate true cylindrical surfaces, and how accurately adjacent surfaces fit each other. It was found that when the diaphragm cover was supporting a weight or was under compression, the distance between it and the film was about $\frac{5}{16}$ of an inch. Probably this distance can be diminished slightly by suitable adjustments. These figures are not claimed to be the best dimensions for a Bucky grid; no doubt they will be improved upon. Preliminary tests with the diaphragm indicate that thicknesses as small as 4 inches can be roentgenographed with advantage. Roentgenographs of the human knee made with this diaphragm show, in addition to the enhanced contrast, better definition and more detail in the bone structure than roentgenographs made without the diaphragm. There are here exhibited roentgenographs of various parts of the body made both with and without the Bucky diaphragm; a close inspection of these roentgenographs will show the advantage of the thin grid in improving roentgenographic definition and detail.

# LOS ANGELES

LOS ANGELES and Southern California are well known throughout the world as the playground of America. You who are coming here, perhaps only for a short time during the convention, will find Los Angeles and its surrounding country a real vacation center in the truest sense of the word. For the benefit of those members of the American Roentgen Ray Society who are planning to spend their vacations this summer in Southern California and attend the convention in Los Angeles, from September 12th to 16th, we shall tell a few things about Los Angeles and list some of the attractions which Southern California has to offer its visitors.

A little over thirty years ago Los Angeles had less than 50,000 people. Ten years later its population had doubled; and by the year 1910 it could boast of an official population of over 300,000. The 1920 census figures showed an increase to 576,673, which figures were revised in July of the same year to a grand total of 611,636 or a gain of in excess of 90 per cent for the ten-year period. This gain was approximately five times the average gain for the United States during the same period. Conservative estimates place the present population at 750,000. Today Los Angeles is the ninth city in population and wealth and the tenth in industry in the United States. During the same period from 1910 to 1920, Los Angeles County's population increased practically at the same rate, from 504,131 in 1910 to 936,455 in 1920, or a gain approximately of 85.8 per cent, which shows very clearly that the growth and development of the country district immediately surrounding the city of Los Angeles has kept pace with the growth of the city itself.

Los Angeles is a city of homes of unsurpassing beauty of every type, from the smallest cottages to the largest mansions. Her lawns are green the year round; and the trees, flowers, shrubbery, and palms are to be seen everywhere. The rare beauty of the grounds surrounding the attractive homes of this city is the constant theme of admiration on the part of eastern visitors. Los Angeles is a city of schools, which are among the best built and the best equipped in the whole country. It has two great universities as well as several large business colleges and colleges of music and art. This city pays a larger tax per capita for schools than any other city in the United States. It is situated

Ocean front at Santa Monica, near Los Angeles.

in the center of a land of almost perpetual sunshine, between the mountains and the sea. Los Angeles is both a winter and a summer resort. From 200,000 to 300,000 tourists come here annually to spend their vacations. One of the many reasons for this is the fact that it is a sportsman's paradise.

It boasts the most highly improved system of highways in the United States, stretching in every direction from the heart of Los Angeles through the great valleys to the mountains and to the ocean. From a spin on any of these fine boulevards one may stop to fish or hunt, for a splash in the surf, or for a tramp in the hills or beautiful mountain canyons. From the ocean to the foothills, through orange groves and rose hedges, these splendid asphalt and concrete lanes invite business and pleasure travel alike.

Within easy motoring distance of the city are scores of pretty little suburban cities, each having its own distinctive charm. Visitors in Los Angeles have little difficulty in selecting a different motor trip for each day of the month, and every one of them is over smoothly surfaced highways lined with roses and orange, lemon, and walnut groves.

Perhaps the most convincing tribute to the highway system of this locality is the enormous number of automobiles in the one county of Los Angeles. Exactly 211,-679 automobiles were registered in this one county on January 31, 1922, which is more than the total registration for any one of thirty-two different states of the Union.

Westlake Park, Los Angeles.

The Los Angeles County coast line contains a varied succession of scenery. In addition it has this great advantage, that the beauties of the beach and the ocean may be enjoyed to perfection every month of the year. Even at midwinter, when the beaches on the Atlantic Coast are deserted, numerous visitors may be seen at the beach resorts on a Sunday or holiday, enjoying a dip in the surf or gathering ocean treasures. Not only is the winter climate beyond all comparison with that of the eastern coast at the same time of the year, but the summer is also far more

pleasant. On the coast there is never an oppressively warm day.

The leading seaside resorts of Los Angeles are Santa Monica, Ocean Park, Venice, Redondo Beach, Long Beach, and Catalina Island. Santa Monica, which is within less than an hour's ride from Los Angeles, is an improved, progressive, seaside city with beautiful homes, a fine beach, and many attractions for the summer visitors. It is famed as the place "Where the mountains meet the ocean."

Long Beach, situated almost due south of Los Angeles, is a thriving city of over 55,000 people, with one of the finest stretches of hard level beach on the coast, and a pleasure wharf 1,800 feet in length. During the past few years the growth of Long Beach has been unusually rapid. Here is located the Virginia Hotel, the scene of many brilliant social events of Southern California.

No one can afford to miss Santa Catalina Island, whose rugged peaks may be seen

Linda Vista Bridge.

Here one may enjoy superb mountain climbing; and in less than an hour descend for a swim in the surf.

Ocean Park, which joins Santa Monica on the south, is built up with neat cottages for a couple of miles along the beach, with a cement walk 4 miles long and 30 feet wide.

Still further south, Venice, which can be reached from Los Angeles in about thirty minutes, is a most unique and attractive resort. With its canals, fine piers, great surf, and bath-house, it is one of Southern California's most popular beaches.

rising out of the haze 20 miles out from Los Angeles harbor. The island is widely known as the greatest big game fishing resort in the world. Santa Catalina is an exceedingly picturesque mountainous island, 23 miles long and about 4 miles wide. It is reached by steamers from either Long Beach or San Pedro. The waters here are so clear that, through the glass bottoms of specially fitted boats making regular trips, wonderful submarine scenes may be admired. With the fish, large and small, swimming about in the forests of kelp, and darting here and there at great

Skyline from Pershing Square.

depths, and with star-fish, sea anemones and other forms of sea life in a bewildering wealth of color and action, one gets a picture never to be forgotten. Here, too, are to be caught the huge sea bass, the great fighting tuna, and the sword fish, for which the ambitious sportsman angles with rod and tackle of such light weight as to make the successful landing of a large fish appear absolutely impossible. The bathing at Catalina is unexcelled anywhere in the world; and there are the night trips to sea with the search lights revealing myriads of flying fish in midair. The hotel accommodations are of the best; and a week will be found all too short to stay on this wonderful island.

The Sierra Madre, or Mother Range, the foothills of which are about 10 miles from Los Angeles, is a romantic and interesting range of mountains. Along this range are numbers of interesting canyons. The two most popular peaks in the Sierra Madre are Mount Wilson and Mount Lowe. The former is reached by a comfortable trail, either by horseback or on foot. Near the summit is an excellent camp where good accommodations are furnished to visitors. The crest of the mountain is a park-like tract shaded by giant pines, from which the visitor looks across a tremendous gorge into the heart of the range. Here is a world-renowned astronomical observatory containing the largest telescope in the world. Mount Lowe is reached by electric cars and cable, the whole forming an interesting and ingenious system of mountain railway which extends to Alpine Tavern, at a height of about 5,000 feet.

So far we have mentioned only a few of the beauty spots of Southern California. If space permitted, we would tell you of Pasadena, famous throughout the world as a city of millionaires, with its magnificent castles, beautiful residences, and luxurious hotels; of Riverside, which is the home of the orange and of the Mission Inn, perhaps the most unique hotel in all the world; of Redlands, with its Smiley Heights; of San Diego, our neighboring city on the south, where among many attractions perhaps the most unusual is the chance to get a glimpse of Old Mexico at Tia Juana; and of numerous other places including our many mountain resorts, of which Big Bear Lake is considered the best known and liked.

And do not forget that Los Angeles is the movie capital of the world. Approximately 80 per cent of the moving pictures of the world are manufactured here, at Hollywood, Culver City, and Universal City, the climatic conditions being unexcelled for photography. This has led

to the development of an industry of large proportions employing thousands of people. Here is where your favorite movie star lives and works, almost without a doubt.

So varied is the topography of Los Angeles city and county that the picture makers find corners of any part of any country in the world in the county, if not in the city. The deserts of Arabia are behind El Segundo, in the sand dunes. The mountains of Switzerland are anywhere in our hills. The Canadian woods are only four hours away, up by Big Bear Lake, with the pines and snow and the mountains. The green sloping hills of Britanny are anywhere along the coast; and the palm-fringed isles of the South Seas are at the mouth of Topango Canyon. The rocky cliffs of Monte Carlo have been located between Long Beach and Redondo. In fact, all the world is here for the convenience of the picture folk.

Some of the studios admit visitors on certain days; and all of them admit visitors with special passes. Visiting members of this convention will have little trouble meeting their favorite movie actor or actress face to face.

However, attractions for the tourist and the visitor, admirable as they may be, do not represent the only attractions to which Los Angeles is proud to lay claim.

Los Angeles' industrial growth has kept up with its growth in population, which is saying a good deal. Figures recently issued by the Chamber of Commerce show that the city now has 3,800 manufacturing establishments of various kinds, of which number 450 were established in 1921. These concerns employ over 125,000 workmen, whose monthly pay-roll runs over $16,000,000. The value of manufactured products from these industries in 1920 was in excess of $788,000,000, as compared with $103,357,000 in 1914, $68,586,000 in 1909, and $15,134,000 in 1900.

Los Angeles has practically the only 365 working-day climate in the United States; and the saving made possible by the climate, both to industrial establishments and to the workers themselves through the medium of better health, lower fuel, cost of clothing, and enjoyment of real outdoor life, is an advantage which will, in time, outweigh the reputation of this locality as a national playground.

Los Angeles, through her wonderful aqueduct system which is the longest in the world, has a supply of pure mountain water sufficient to take care of over 3,500,000 people; and can increase the supply through additions whenever it becomes necessary. In the last ten years it has actually been increased from 14,600,000 gallons

Wilshire Boulevard near the Ambassador Hotel, Los Angeles.

to 30,000,000 gallons in the city alone; and from 91,000 water service in operation in 1910 to over 230,000 in operation at the present time. The water flows through 52 miles of tunnel, 12 miles of siphon, 100 miles of lined and covered conduit; 40 miles of open lined canal, 21 miles of open unlined canal and 8½ miles of reservoirs. It is to the abundance and cheapness of her water supply that Los Angeles owes much of her prosperity and her ability to grow.

Los Angeles is the geographic center of the Pacific Coast of the United States for trade with the west coast of Mexico and South America, and for trade with the eastern ports of the United States through the Panama Canal. And, what is even more important, Los Angeles considers itself the natural port of the Pacific to receive the bulk of the commerce that in the near future will be exchanged between the United States and the great countries of the Orient—China, Japan, Australia, the Philippines, and Russia. It is determined to hold every advantage it has in being situated at the entrance to all these enlarging markets. Consequently $20,000,000 has been spent or appropriated for the development of its harbor, the object being to provide adequate facilities for warehousing and docking at the lowest possible rates.

Over sixty steamship companies, having vessels in international service, operate through Los Angeles harbor. Its commerce has increased from approximately 2,100,000 tons in 1918 to almost 5,000,000 in 1921.

That Los Angeles has been building on a firm foundation is evidenced by the way her growth has continued during the period of recent depression. The value of her building permits has been the wonder of the whole country since the early months of 1920. During that year the value of building permits amounted to $60,023,600. 1921 went over with a vengeance and rang up a total of $82,761,286. But the present year promises to set an even greater record with a total of over $39,000,000 for the first four months of the year.

Los Angeles bank clearings have been very conspicuous during the last two years because of their increase at a time when practically every other city of the country was registering losses. From $1,048,090,667 in 1910, bank clearings have increased to $3,994,401,000 in 1920, and $4,211,196,797 in 1921. What better testimonial could be written on the continued growth and prosperity of a great city?

Looking North on Broadway from 7th Street.

We could tell you much more about this wonderful city and its surrounding back country; but what we have said is sufficient, we believe, to impress upon your minds the fact that, while Los Angeles and Southern California continue to be the playground of the nation, they are rapidly becoming the industrial, financial, and population center of the west as well. And we are sure that you will want to come and see for yourselves.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY

LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922

*Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.*

## AMERICAN ROENTGEN RAY SOCIETY

### TWENTY-THIRD ANNUAL MEETING

### PRELIMINARY PROGRAM

For many years our far western members have been making every effort to persuade us to meet on the Pacific Coast; at last they have succeeded. The twenty-third annual meeting of the American Roentgen Ray Society is to be held in Los Angeles, California, September 12th to the 16th, 1922.

The members of the various local committees have been unusually active in their efforts to make our visit both comfortable and attractive.

The Hotel Ambassador has been selected as the meeting place; it is one of the best hotels in the west. Special attention is to be given to members and guests. The hotel management has provided a comfortable, well-ventilated meeting room, where our scientific sessions are to held; spacious quarters are assigned to accommodate our scientific and commercial exhibits.

The scientific program will have as much, if not more than its usual attractiveness. The following accepted papers will give some idea as to the scientific treat to be expected:

#### MISCELLANEOUS

HICKEY, DR. P. M., Detroit, Mich. "The Effects of the War on the Development of Roentgenology."

PAHLERR, DR. G. E., Philadelphia, Pa. "A Study of the Blood of the American Roentgenologist."

WATKINS, DR. W. W., Phoenix, Ariz. " The Commercial Laboratory in a Small City."

#### NEUROLOGY

CROUSE, DR. H. W., El Paso, Tex. "The *X*-Ray in Neurological Diagnosis—Its Shortcomings and Possibilities." (By invitation.)

#### HEAD

RUGGLES, DR. H. E. and SCHULZE, DR. ELIZABETH, San Francisco, Cal. "The Importance of Proper Technique in the Determination of the Sphenoidal Angle." (Dr. Schulze, by invitation.)

LAW, DR. F. M., New York City. "Errors in the Interpretation in Lesions of the Sinuses."

EVANS, DR. WM. A., Detroit, Mich. "Roentgen Study of Mastoid Pathology in Children under Five."

#### BONE

BLOODGOOD, DR. JOSEPH C., Baltimore, Md. Title unannounced.

COTTON, DR. ALBERTUS, Baltimore, Md. "The Roentgenologist in the Diagnosis and Interpretations of Fractures."

KEITH, DR. D. Y., Louisville, Ky. "The Value of Grant's Pins as seen Roentgenographically in the Treatment of Fractures."

BROWN, DR. W. L., El Paso, Tex. Title unannounced. (By invitation.)

George, DR. A. W., Boston, Mass. Title unannounced.

#### JOINT

CHAMBERLAIN, DR. W. E., San Francisco, Cal. "Lower Back." (By invitation.)

BLAINE, DR. E. S., Chicago, Ill. "Bilateral Sacroiliac Arthrosis Obliterans and Its Probable Etiology."

TAYLOR, DR. R. G., Los Angeles, Cal. "Roentgen Gastrointestinal Studies in Over One Hundred Cases of Chronic Deforming Arthritis." (By invitation.)

#### URINARY TRACT

NICHOLS, DR. B. H., Cleveland, Ohio. "The Importance of Technique in Roentgen Examination of the Urinary Tract."

Bowman, DR. W. B., Los Angeles, Cal. Title unannounced.

#### CHEST

SANTE, DR. L. R., St. Louis, Mo. "Roentgenographic Examination of Lobar Pneumonia and Its Complications."

JACHES, DR. LEOPOLD, New York City. "Pulmonary Tuberculosis."

DUNHAM, DR. KENNON, Cincinnati, Ohio. "*X*-Ray Evidence of Absorption of Tuberculous Exudate."

PIRIE, DR. A. HOWARD, Montreal, Canada. "Prognosis in Tuberculosis of Lungs from Examination by *X*-Rays."

CHRISTIE, A. C., Washington, D. C. "Intrathoracic Changes Following Roentgen Treatment of Breast Carcinoma."

ALLISON, DR. R. G., Minneapolis, Minn. Title unannounced.

BROWN, DR. PHILIP KING, San Francisco, Cal. "Annular Pneumothoraces." (By invitation.)

CHILDS, DR. S. B. and HALL, DR. J. N., Denver, Colo. "New Growths Within the Chest." (Dr. Hall, by invitation.)

MATSON, DR. R. W., Portland, Oregon. (By invitation.)

HOLMES, DR. G. W., Boston, Mass. "Cardiac Pneumofibrosis."

WATERS, DR. C. A., Baltimore, Md. "Bronchiolitis Fibrosa Obliterans."

MOORE, DR. A. B., Rochester, Minn. "Bronchiectasis."

BOWEN, DR. D. R., Philadelphia, Pa. "Thoracic Empyema with Especial Reference to Interlobar Types and to the Study of Chronic Empyema."

MANGES, DR. W. F., Philadelphia, Pa. "Our Technique in Aiding with the Fluoroscope in the Removal of Foreign Bodies from the Air Passages."

## GASTROINTESTINAL TRACT

### ESOPHAGUS

MANGES, DR. W. F., Philadelphia, Pa. Title unannounced.

### STOMACH AND DUODENUM

ALVAREZ, DR. W. C., San Francisco, Cal. "Peculiar Types of Gastric Peristalsis."

FORSSELL, DR. GÖSTA, Stockholm, Sweden. "Roentgenographic Studies of the Mechanism of Movement of the Mucous Membranes in the Digestive Tract."

CARMAN, DR. R. D., Rochester, Minn. Title unannounced.

IMBODEN, DR. H. M., New York City. "A Further Consideration of the Intermittent Obstruction of the Duodenum."

### GALL-BLADDER

BURNHAM, DR. M. P., San Francisco, Cal. "Importance of Indirect Roentgen Findings in Chronic Infection of the Biliary Ducts and Gall-bladder."

### SMALL INTESTINES

PORTIS, DR. MILTON M., and PORTIS, DR. SIDNEY A., Chicago, Ill. "Carcinoma of the Small Bowel."

### COLON

PAYNE, DR. R. A., Portland, Oregon. "Retrocecal Appendix."

LEWALD, DR. L. T., New York City. "Report of Twenty-five Cases of Transposition of Viscera. Differential Diagnosis Especially from Non-rotation of Colon and from Dextrocardia."

BOARDMAN, DR. W. W., San Francisco, Cal. "Enteroliths."

JENKINSON, DR. E. L., Chicago, Ill. "Report of Three Cases of Primary Carcinoma of the Gastrointestinal Tract with Bony Metastasis."

## THERAPY

OSMOND, DR. J. D., Cleveland, Ohio. "*X*-Ray Treatment of Acute Infections of the Antrum and Frontal Sinus."

KINNEY, DR. L. C., San Diego, Cal. "Roentgen Therapy of Tinnitus Aurium."

WATERS, DR. C. A., Baltimore, Md. "Further Report on Roentgen-ray Treatment of Hypertrophied Tonsils."

ULLMANN, DR. HENRY J., Santa Barbara, Cal. "The Bacteriology of Irradiated Tonsils."

LEDOUX-LÉBARD, DR. RENÉ, Paris, France. Title unannounced.

GAYLORD, DR. HARVEY R., Buffalo, N. Y. Title unannounced. (By invitation.)

CASE, DR. JAMES T., Battle Creek, Mich., and WARTHIN, DR. A. S., Ann Arbor, Mich. Title unannounced. (Dr. Warthin by invitation.)

SCHMITZ, DR. HENRY, Chicago, Ill. "The Technique of Radiation Treatment of Cancer of the Uterus." (By invitation.)

SOILAND, DR. ALBERT, Los Angeles, Cal. "Conservation—the Keynote of Superradiation."

ERSKINE, DR. A. W., Cedar Rapids, Iowa. Title unannounced.

HOLZNECHT, DR. GUIDO, Vienna, Austria. "Conservative Deep Roentgen Therapy." (Paper to be read by Dr. W. C. Wescott of Atlantic City, N. J.)

MILLWEE, DR. R. H., Dallas, Tex. "Some Observations on the Practical Application of High Voltage *X*-Rays."

STEVENS, DR. J. T., Montclair, N. J. "Report of Cases Showing Favorable Results of Deep Roentgen Therapy."

MARTIN, DR. C. L., Dallas, Tex. "The Effect of the Erythema Dose on the Intestinal Tract."

DESJARDINS, DR. A. U., Rochester, Minn. "Anatmical Cross-section Charts in Estimating *X*-Ray Dosage."

Readers of papers are asked kindly to forward abstracts for publication in the program as soon as possible.

An entire afternoon is being reserved for the lantern slide demonstration—this is always a very valuable addition to the scientific program, and every member is urged to contribute. In conjunction with the lantern slide exhibit the "sealed verdict" cases will be considered.

The lantern slide presentation is not limited to members only. Any guest of the Society has the privilege of reserving a place on this program.

Kindly send in your name as soon as possible and indicate the number and nature of the slides you intend to show. Address all communications, regarding lantern slides or "sealed verdict" cases, to Dr. William B. Bowman, 818 Brockman Bldg., Los Angeles, Cal.

There will be no scientific session in the evening except on Wednesday, September 13th, when Dr. William Duane of Harvard University will deliver the Caldwell Lecture —entitled "The Scientific Basis of Short Wave-Length Therapy."

On Thursday evening, there will be a dinner-dance to which the members and guests and their wives are invited.

Among the many social events arranged for by the Local Committee is an automobile trip on Saturday, the 16th, and also a sail to the Catalina Islands on Sunday, the 17th.

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Pertinent questions of today in the field of roentgenology and roentgen or central bone ray therapy:

Have you a case on record of a periosteal sarcoma cured with *x*-ray or radium?

Have you had any experience with infinitesimal exposure of the pituitary gland to the *x*-ray in the treatment of deafness?

Have you any cases where you feel that *x*-ray treatment of the breast has caused the development of non-malignant changes in the lungs sufficient to be recognized roentgenographically? If so, how do you differentiate these changes from pulmonary metastasis?

All affirmative answers will be considered at the Los Angeles meeting. Kindly communicate with the President-Elect, Dr. W. H. Stewart, 222 West 79th Street, New York City.

## ARRANGEMENTS FOR TOUR

Numerous members of the Society have expressed a desire to combine a tour of the western country with their trip to the Annual Meeting, and arrangements have been made for such a tour under the personal supervision of an experienced tour manager, Mr. E. R. Rochester, who will himself accompany us and care for all the details of travel.

A circular giving complete information with regard to expense, the proposed itinerary, and the time of arrival at and departure from principal points will be sent upon request to the undersigned.

There is no objection to the members of the Society inviting friends who are not members to accompany our party.

It is requested that all who are interested, or desire further information, correspond with the undersigned. Reservations for the trip should be made as soon as possible.

A. C. Christie, President
American Roentgen Ray Society,
1621 Connecticut Ave., N. W.,
Washington, D. C.

Note: There is still time to make reservations if communication is sent at once to Dr. Christie.

## DR. HEBER ROBARTS

Dr. Heber Robarts, a native of Belleville, Ill., died May 1, 1922. His death was due to a general metastasis following *x*-ray burns developed during the pioneer days of experimental research with the roentgen rays.

Heber Robarts, M.D.

His father, Dr. James Robarts, a physician of great skill and learning, was actively interested in McKendree College, and in 1869, his son Heber was admitted to this same college at the age of seventeen, and soon afterward became an active member of the Philosophian Society.

After attending two courses of lectures at Jefferson Medical College, Philadelphia, he entered the Missouri Medical School and graduated as a physician in 1880.

During the early years of his life he was actively interested in the medical problems of his home state. In 1881 he served as

secretary of the board of the United States Examining Surgeons, and later was appointed by the governor of his native state as a delegate to the Sanitary Convention of the Mississippi Valley and Gulf States. He was always interested in Health Departments and Health Ordinances, and he was the author of many of the latter which are practical models of efficiency even today.

He began experimenting with radioactive substances over twenty years ago while living in St. Louis. The first high frequency coil made for generating high voltage to excite an *x*-ray tube was made under his instruction. The instantaneous cut-off in the handle of the fluoroscope and the pocket for the sensitized plate were his early conception. He was likewise a pioneer in the advocacy of the *x*-rays in the treatment of lupus and other inflammatory skin infections, and very early realized both the safe and dangerous use of the rays in epilation.

In 1897 he published the initial number of the *American Roentgen Ray Journal* which was the first regular publication upon this subject in the world.

In 1890 the Roentgen Ray Society was organized, and he was its first president, presiding at the meeting in New York City in December, 1900, and at the Buffalo meeting in September, 1901.

During the year 1904 he went to Europe to procure radium and to study its physics and therapeutic application. He was the first to use aluminum carriers for radium, and the first to publish a bound volume devoted to the therapeutics of "Practical Radium." His most recent articles published were "Ions Produced by Radium;" "Radioactive Tissues;" "Radium;" "Thorad-*X*;" "Radium Applicators."

During the year 1905, with the aid of several Italian guides, he reached the crest of the crater of Vesuvius, and although the volcano belched forth sulphurous fumes, ashes, and lava, he procured samples of these ashes, and established the fact that radio-active matter is not confined to the thin crusts of the earth's surface.

He was in Austria in 1914 shortly before the war and purchased radium. He had considerable trouble on his return voyage, but eventually placed it at the disposal of St. Vincent's Hospital; and it was this same radium that he made use of in the treatment of his own condition.

Those who knew Dr. Robarts personally will bear testimony to the extreme interest he showed in medical science as a member of the local and state societies, including the American Radium Society and the Roentgen Ray Society of London.

In giving his life to the cause of science it should be remembered that Dr. Robarts made this supreme sacrifice only after the culmination of a series of lesser sacrifices, extending over a period of many years of suffering, meanwhile fulfilling his duties as only a true physician could do when the welfare of his patient was at stake.

EDWIN C. ERNST.

## A CORRECTION

In the article by Dr. R. Walter Mills on Small Intestinal States which appeared in the April, 1922, issue of the JOURNAL there were two typographical errors.

On page 209, legend of Fig. 25, line 5, the word "hypomotility" should read hypermotility."

On page 222, in the last line of the article, the reference to Fig. 37 is incorrect. It should be Fig. 49.

*Subscribers to* THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

# TRANSLATIONS & ABSTRACTS

BAILEY, HAROLD, AND QUIMBY, EDITH. The Use of Radium in Cancer of the Female Generative Organs. (*Am. J. Obst.*, February, 1922, iii, No. 2.)

This paper discusses the methods of radium therapy in the treatment of uterine cancer in use at the Memorial Hospital, and describes the efforts to determine accurately the dose by ionization measurement. There were 600 cases of uterine cancer and 32 cases of vulval and vaginal cancer treated in the six years from 1915 to 1921. The follow-up of these cases extends to May 1, 1921.

The full technique, using the external radiation as an aid to the capsule and bomb was not in routine use until 1918. If the advanced primary cancer and the recurrent cancer groups were taken together, there were 132 cases treated before January 1, 1918, and there are but 5 cases alive today. If these same groups are taken for 1918, there are 76 cases and 15 are alive; for 1919, 112 cases and 40 are living; for 1920, 129 cases and 85 are still alive. While the prospects of greatly reducing these figures are present and sure, nevertheless, the indications are that in these groups, we have had our greatest advance.

The follow-up of our operable and borderline classes will have to be continued through three or four more years before deductions may be made. Our present figures are remarkable and indicative.

In the prophylaxis after hysterectomy, great care must be used that the tissues are not over-radiated. The end results in this class are very good for the time elapsed since treatment.

We believe that these results cannot be duplicated without the use of massive doses of radium or without thoroughly radiating the parametrium.

FUNK, E. H., AND MANGES, W. F. Eventration of the Diaphragm, with Report of a Case. (*Am. J. M. Sc.*, September, 1921, p. 348.)

Eventration of the diaphragm is known in the literature under several different heads. Such terms as "high position," "elevation," "dilatation," "relaxation" and "congenital insufficiency" are used. In 1916 45 cases had been reported, including one reported by Bayne-Jones. Since then, two cases have been encountered, which, with this case report brings the total number of cases to date up to 48.

The weight of evidence seems to favor a congenital origin of the condition. The authors note one case in a patient a few days old where the diaphragm reached to the 2d interspace.

Some arguments for the congenital nature of the condition are:

1. Its occurrence on the fetus and newborn.
2. Its association with other congenital anomalies.
3. Involvement of the left side almost entirely—this being the half of the diaphragm most complex in its fetal origin.
4. The absence of compression of the lung and contiguous structures.
5. The absence of deformity or irregularity in the contour of the chest.

A detailed report is given of the clinical history and physical findings in the case reported. The *x*-ray findings showed the left diaphragm considerably higher than the right and that it did not move on forced inspiration. No other evidence was present of disease of the lungs. No adhesions were present to the diaphragm. There was enormous distention of the colon with gas, but it was not thought that this had any influence on the height of the diaphragm.

Among the reported cases the left half of the diaphragm was the site of involvement in all except 3 cases. The dome was regular in outline and it was not associated with adhesions of the pleura. L. R SANTE.

TAUSSIG, FRED J. Radiotherapy in Malignant Gynecologic Diseases. (*J. Missouri M. Assn.*, 1921, xviii, No. 7, p. 224.)

The term radiotherapy includes treatment both with radium and *x*-rays. In benign gynecologic conditions these two are of nearly equal importance, but in the treatment of malignant conditions radium has many evident advantages, so that the *x*-ray is usually only supplementary to it and has seldom been used as an independent therapeutic agent. The personal experience of the author is given as 120 cases, 109 of which were cervical cancer treated during a period of three and a half years. He does not consider this number of cases sufficient and prefers to draw conclusions as to the ultimate usefulness of radium and *x*-ray from the much larger number of published cases.

The surgical treatment of cancer of the body of the uterus with 75–80 per cent cures leaves little excuse to employ radium.

In cervical and vaginal cancer, the problem is to destroy the growth with the least possible

injury to the surrounding structures. Normal tissues vary greatly in their susceptibility to injury by radium. The cervix can stand ten times the dose safe for the vagina and fifteen to twenty times the dose tolerated by the rectum. Our aim therefore should be to so place the radium within the cervix that the entire tumor mass would be affected by the first treatment period, since by subsequent treatments the normal tissues become more susceptible and tumor tissue more resistant to radiation.

Diminution of the bleeding and discharge and temporary alleviation of pain will follow in the vast majority of cases, but this is of little significance as a criterion of the ultimate outcome. In the experience of a few men radium has been employed for a long period, so that at least some five-year experiences are available.

Out of 1114 cervical cancers, all stages treated with radium alone, 223 cases remained cured five years (about 20 per cent). Of 415 operable cases 131 remained cured after five years (31.5 per cent). This is about the same as has been obtained by operative measures alone. In early operative cases it was found that radium cured 35–40 per cent; whereas operation cured 45 per cent. In advanced operable or borderline cases, however, radium cured 23 per cent, while operation cured only 10–12 per cent. The author feels that where carcinoma is confined to the cervix, operation is still indicated, where in borderline and inoperable cases, radium and *x*-rays hold forth the greatest hope of cure. L. R. SANTE.

SMITHIES, FRANK. Diagnosis and Clinical Manifestations of Cardiospasm Associated with Diffuse Dilatation of the Esophagus. (*Am. J. M. Sc.*, September, 1921, p. 313.)

The paper is based on an observation of 76 instances of cardiospasm and a detailed analysis of 47 cases. A distinction is made between "Cardiospasm" and "spasm of the cardia," the term cardiospasm being applied to those cases in which, due to long-continued contraction of the cardiac sphincter, a diffuse dilatation of the esophagus results. The condition was found to be of equal prevalence in men and women. The average age was thirty-nine years; the youngest nineteen and the oldest seventy years of age. Occupation played very little part, and other ailments, except in very few instances, had very little association with the condition. The average duration of the condition was 5.6 years. Individual cases varied from three months to twenty years. Dysphagia was the most striking symptom.

The *x*-ray is given due credit in the diagnosis of the condition. Emphasis is laid on the oblique and anteroposterior positions for determining the position of the spasmodic contraction and for showing any irregularity in the lower end of the esophagus. Illustrations are presented showing similarity which can exist between the *x*-ray appearance of uncomplicated cardiospasm and a dilatation of the esophagus in association with carcinoma of the lower end of the esophagus. Fluoroscopic examination is of aid in passing a stomach tube or bougie into the stomach; but a procedure advocated by Mixter of Boston seventeen years ago, is thought to be the best method of passing a tube into the stomach. This consists in guiding a tube to the cardiac orifice along a silk cord attached to a metallic olive previously swallowed. An instance is cited of false passage of a bougie and death, where this procedure was not followed. Mention is made of an irregularity of rate of movement of the diaphragms in cases of cardiospasm and an increase in height of the dome of one diaphragm, which leads the author to the belief that cardiospasm may have some connection with a defect in the neuromuscular control of the diaphragm. Seventy per cent recover clinically and functionally. Twenty per cent show improvement, and in about ten per cent gastrostomy is necessary.

L. R. SANTE.

PARTSCH, F. Effect of Roentgen Rays on Liver and Spleen. (*München. med. Wchnschr.*, 1921, lxviii, No. 50.)

In only a small percentage of his cases did the author find a decrease in the coagulation time of the blood at operation, as the result of a prophylactic application of roentgen rays to the spleen. Neither did he find any proof that the pre-operative application acted in any way to prevent post-operative complications, such as hemorrhage or hematoma. As regards the liver, irradiation was as uncertain as in prophylactic treatment directed toward the spleen. Therefore, from the view-point of the practical surgeon, it is quite useless to employ prophylactic irradiation of either the liver or the spleen, except perhaps in cases of hemophylia, jaundice, or others with marked retardation of the blood coagulation time.

NORDENTOFT, S. Roentgen-Ray Treatment of Brain Tumors. (*Ugesk. f. Laeger*, January 19, 1922, lxxxiv, No. 3.)

This article reviews the present condition of 18 patients with brain tumor treated with roentgen rays prior to 1919. Four new cases are reported, bringing the total number treated

up to 24. In 7 cases of the first series, improvement was transient or not observed at all; in 2 others it was later proved that the diagnosis was incorrect. In 9 patients the treatment has apparently resulted in cure. Visual disturbances remain in a few of the patients. The cures had persisted four, or five or six years in the 9 patients reported apparently cured in this series. The author believes that brain tumors are especially susceptible to the roentgen rays. In those cases responding favorably to the treatment, there is no tendency to recurrence. The ages varied from seventeen to fifty-one. Full details of the cases are given.

Moll, K. (Freibourg). Deep Roentgen Therapy in Surgical Tuberculosis, Bruns' Beitraege. (*Beitr. z. klin. Chir.*, 1920, cxix, p. 445.)

In 1914 Oehler made the first report from this (Kraske's) Clinic on deep roentgen therapy of this group of affections. During the ensuing four years a much larger series of cases has been treated. Tuberculosis lymphoma, chiefly of the neck, has greatly predominated. In 1918 alone 102 cases have been under treatment and during the four year term a total of 263. Deep rontgen therapy is by all odds the method of choice for this condition. Of the total number under treatment no less than 219 were practically cured by it alone. Only in a few instances was it desirable for cosmetic reasons to remove the small fibrotic nodules which could not be further reduced in size. Caseous and fistulous cases recovered equally with the simple hyperplastic cases, save that scarring persisted. The response to treatment was immediate and the improvement very noticeable after two or three sessions. To complete the cure, time is required, and the author neglects to state the average duration of treatment. That 44 cases of lymphoma were not cured shows the limitations of the method; for while in some of these there was a greater or less degree of improvement, in others there was no benefit, or the improvement was followed by recurrence.

The series of cases of bone and joint tuberculosis numbered 171, and the results were so uniformly good that in but 19 of these was a mutilating operation necessary. The best results were obtained in diseases of the hands, wrists and elbows. It is a law that the more slender and superficially placed the bone the better the result; and for this reason the results were good in the few cases of tuberculosis of the ribs and sternum. Of the bulky joints the knees responded best to the treatment. Of 29 cases in this location 17 were cured without a trace of disease remaining. There were relatively few cases of surgical tuberculosis in other locations and results were in general less favorable.

Markovits. Concerning the Influence of Mesothorium on Unicellular Organisms. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 1.)

The experiments of the author by irradiating paramaecium caudatum with 10 milligrams of mesothorium confirmed the biological fundamental law of Arndt-Hugo Schulz. After short irradiations (ten to ninety minutes) a marked increase in the propagation of the animals occurred. Larger doses, however, paralyzed or killed them. Previous experiments with plants and seeds had also confirmed this fundamental biological law.

Lyon. Spondylitis Typhosa. (*Berl. klin. Wchnschr.*, 1921, No. 18.)

According to the author, spondylitis typhosa is a sequel, and rarely a complication of typhoid fever. It occurs anywhere in the spine, beginning with the cervical area down to the sacrum, most frequently, though, in the fourth lumbar vertebra. Inasmuch as the symptoms are very slight, the roentgen-ray findings may be the first to call attention to this condition. In one case nothing abnormal was noted about the spine besides the *x*-ray finding. The process almost always runs a benign course. Formation of kyphosis is rare. The author quotes the monograph of Bonhure (1912) who observed as the most constant lesion a coalescence between two vertebrae, changes of the intervertebral discs, and thickening of the perivertebral tissues, more rarely slight lesions of the bodies of the vertebrae.

Bittorf noted greater transparency of the bodies of the lumbar vertebrae and bending of a transverse process. According to Plate, spondylitis typhosa occurs most frequently in men under forty, spondylitis deformans in men over fifty. The roentgen-ray finding shows no exact differences.

According to Schanz, trauma may play an important rôle. (Haenisch, of Hamburg, has in his collection the plates of a case of spondylitis typhosa which has the appearance of a compression fracture or of a healed tuberculous spondylitis. The process occurred in the lower spine. Reviewer's Note.)

Lüdin (Bâle). Roentgen Therapy in Internal Medicine. (*Schweiz. med. Wchnschr.*, Nov. 24, 1921.)

The author is an assistant of Professor Stähelin of the internist's clinic of the University. The paper is based on a material of

600 cases, referred to the department of physical therapeutics for treatment. The author has no iontoquantimeter for measuring his dosage and has had to depend on the old Sabouraud-Noiré pastilles. The unit—so-called skin unit—dose is reached by application of 3 to 4 Sabouraud units under 4 mm. aluminum. In internal indications, save in inoperable tumors, successful results have been obtained with single dose under H. E. D. (skin erythema dose). Fixed numerical doses cannot at present be given in internal cases, because there is individual variation and because doses must often be experimental. Nothing can be inferred from gynecological deep raying aside from cases of malignant tumors.

The author first takes up leukemia, the oldest internal indication for *x*-rays. For the chronic myeloid form this treatment is still *the* method. Thus far no case of complete recovery is claimed, but one patient has been able to work for the past eight years. The chief symptoms, enlarged spleen and increased leucocytes in the blood, can be promptly controlled. But after this feat we are pretty sure to see a prompt recurrence. The author therefore regards intensive treatment of these cases as an error. Treatment should be directed to bringing up the hemoglobin index and red cell count, and to the general condition. After these are satisfactory there may be long periods between courses of treatment, even if the spleen and white cell count are still unsatisfactory, and despite the presence in the blood of myelocytes. Not infrequently the latter do disappear from the blood, although the mast-cells may show a great increase. The patient must be kept under constant observation. When the quiescent although usually still enlarged spleen begins to increase further in size, and the white cell count to increase further, radiation should be resumed.

Under this plan of treatment the patient may follow his occupation for years, although this is not the rule. In addition to the case of eight years' activity already mentioned, the author has had one of four years. At the other extreme some patients are so little helped that the rays must be discontinued.

In chronic lymphatic leukemia the results are not so good, but still, some patients have kept active for years. In the acute myeloid form the rays are quite worthless, and this is also true of Banti's disease.

In aleukemic lymphadenosis the results are quite favorable, and a case is given.

In Mickulicz's disease the author obtained a perfect result in one case, all the glandular swellings becoming reduced to normal.

In malignant granuloma the results in some cases were surprisingly good, and two examples are given. Such cases have been common in the clinic. But after a period of latency there is apt to be a recurrence, which, even if not extensive, may affect some vital organ. The affected tissues are specifically attacked and destroyed and the recurrences appear in parts of the body which have not been rayed. Therefore as far as possible all the lymph-nodes in the body should be rayed.

In polycythemia we now know that it accomplishes nothing to ray the spleen. In fact, the author avoids raying it at all, and since he adopted this course his results have been very good (3 cases). In primary polycythemia the long bones are rayed.

The results were absolutely negative in pernicious anemia and chlorosis, and in Basedow's disease it is very difficult to interpret the results. In certain cases some of the symptoms show improvement. The author denies that adhesions form about the thyroid and interfere with surgical intervention.

In lymph-node tuberculosis the results are good, and weak doses are best, for strong ones precipitate softening. The author is also full of praise for the results obtainable in peritoneal tuberculosis.

The author has nothing to offer in the treatment of sciatica which is praised by French authors. All cases in the clinic yield to a mixture of physical and drug therapy.

He was very skeptical about raying erysipelas, but obtained 6 striking result in succession; he is not quite ready to claim it as specfici and ideal treatment.

In mediastinal tumors he has obtained good results without wishing to claim too much.

He is less enthusiastic about internal malignant tumors and thinks the rays are not making good here. Intrathoracic and intra-abdominal cancer, etc., have given results which are quite unfavorable.

He has some hope in the field of otosclerosis and progressive deafness, and the rays certainly exert a specific action on the process, but it is too soon to go on record on this condition.

LOREY. Spondylitis Typhosa. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 1.)

The author quotes a case in which he considers the roentgenologically demonstrated compression of the 12th thoracic and 1st lumbar vertebrae as the result of typhoid which the patient passed through some time before. The pains in the back which appeared during the course of the typhoid and which radiated

into the thighs still existed at the time of the roentgen-ray examination. The appearance resembled very strongly a very old compression fracture or a healed tuberculous process, but trauma and tuberculosis could be excluded etiologically or clinically. The cause of the compression, according to Fraenkel, is to be found in the numerous small necrotic foci which occur in spondylitis typhosa next to the trabeculae of the spongiosa, which in consequence becomes necrotic, the bone eventually collapsing as a result of weight. But Lorey also believes that a breaking down of the bony tissues through pus formation is possible. Notwithstanding the generally favorable prognosis, the author does not wish to have the disease treated lightly (prolonged rest in bed is necessary), because there may be a collapse of the diseased vertebrae with secondary spondylitis deformans, and rigidity of the spinal column may result.

HAENDLY. Pathologic and Anatomic Results of Radiotherapy. (*Strablentherapie*, 1921, xii, No. 1.)

The author, after a series of thorough pathological and anatomical examinations found that retrogressive changes were caused by radiation on all body cells (epithelioma, connective tissue, muscle, vessels and nerves); also that complete necrosis of entire organs may occur. New formation of connective tissue is far behind the damaging influence of the rays. The effect of the rays upon the uterine muscle and upon myoma is, according to the author, largely a direct one. The white blood corpuscles are the most sensitive, but the change in the red blood corpuscles is the most important and has as a consequence a particular form of cachexia, which has no relation to the cachexia of carcinoma. Warnekros has employed, with success, blood transfusions in such cases. An appreciable increase of metastases with a stimulating effect was not observed by the author. Regarding the primary point of attack of the rays, there is no consensus of opinion among the various authors. Some believe that the rays injure the individual cells directly, while Ricker takes the stand that injury to tissues is caused secondarily by the injury to the blood supply; that by stimulation of the dilators which remain sensitive longest, the blood circulation is retarded and finally becomes stagnant. The observations of Haendly have led him to conclude that the rays have a direct effect and also an indirect influence by altering the circulation of the blood. In 125 cases of carcinoma previously irradiated, which came to autopsy, the author was able to demonstrate almost always, degenerative changes of the connective tissue, although very frequently much viable-carcinomatous tissue was present. He therefore refutes the theory of the absolutely selective effect of the rays on carcinoma, and says that the normal tissues regenerate more easily, and that carcinoma which is poorer in cells may lose its regenerative power more readily. The irradiations must take place at intervals sufficiently large to enable a regeneration of the destroyed cells in the normal tissues. The roentgen rays are superior to radium, because of their greater and more homogeneous effect in the depth of the tissues.

GALLUS. Spondylitis Typhosa. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 1.)

The author recites the case of a young man in whom severe pain in the lumbo-sacral region led to a roentgen-ray examination which demonstrated only very minute concretions, at the third lumbar vertebra. Soon thereafter he came down with an atypical form of typhoid fever, but the next roentgen-ray examination (six weeks later) showed a loss of the bony structure of the third lumbar vertebra and compression of that vertebra. A roentgen-ray examination six months later, when the patient no more experienced any symptoms, showed scoliosis of the lumbar spine, marked narrowing of the intravertebral space, and processes of repair. This case is instructive roentgenologically because the observations were made from the incipiency of the disease to its cure.

ELVING, H. Measures for Promoting Blood Coagulation. (*Finska Läk.-sällsk. handl.*, 1921, lxiii, Nos. 11 and 12.)

Elving studied the coagulation time of the blood of normal individuals, finding that there is little variation in the normal. He then carried out a series of experiments to determine the effects of roentgen-ray treatment over the spleen, liver, and heart as compared with the effect of the intravenous injection of various substances. Roentgen-ray exposures over the spleen resulted in a moderate acceleration of the coagulation time in all but one of 12 cases. The accelerating effect was most marked by the end of five hours, and persisted through the eighth hour. At 24 cm. target skin distance, the author administered one third of a skin erythema dose. The use of ice bags and other cooling measures was not found efficacious. The best means for shortening the coagulation time was the intravenous administration of a 10 or 15 per cent solution of calcium chloride, in doses of 10 to 20 c.c.

BLUMENTHAL AND TUGENDREICH. Concerning a Peculiar Favorable Influence of Roentgen Rays on a Tumor of the Skull. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, No. 2.)

A malignant tumor, probably osteo-sarcoma, arising in the vertex of the skull, operation having been refused, was treated with four series of intensive radiations (0.1 mm. lead and 1 mm. aluminum filters) and by intra-muscular injections of large doses of arsenic and iodine (Alival); externally the tumor changed very little, but the general condition of the patient was materially improved. The objective symptoms choked disc disappeared. The roentgen-ray finding, after the irradiation, showed a *complete separation* of the tumor from the healthy tissue by a zone transparent to *x*-rays. The authors leave the question open as to how much irradiation through the lead filter and how much the iodine-arsenic injections have contributed to the favorable result. Important, however, is the fact that the tumor, which is generally considered insensitive to the rays, has lost its malignancy by encapsulation.

BÉCLÈRE, A. What May One Hope and What Fear in the Use of Deep Radiotherapy? (*Presse méd.*, Nov. 23, 1921.)

Béclère answers these questions with reference to radiotherapy of deep organs with very penetrating rays. As the doses employed decrease from surface inwards, both because of the distance and because the superficial layers are able to absorb penetrating rays, different artifices of technique become necessary, the chief of these being cross firing. These partially offset the disadvantages, but it is only recently that rays have been produced which are not arrested extensively by the first few centimeters of surface tissues. These very penetrating rays have been obtained by increased voltage and a more intense filtration. At first the French experts were distanced by the men of other countries in obtaining these penetrating rays, but they are now catching up.

The very penetrating rays hold out much promise and represent an advance which is admirable. One may feel certain that our results in raying malignant growths will improve, be more thorough and more lasting. Seitz and Wintz obtained in this manner 23 out of 24 histological cures of cancer of the cervix. But these rays need not be regarded as a universal advantage, for some affections, like tuberculous glands, do better under the older methods.

Nor are these very penetrating rays wholly exempt from danger. In leukemia, Rosenthal, who sought to cure by intensive methods, lost 3 of his 11 patients, the symptoms being pernicious vomiting, cardiac insufficiency and dyspnea. In cancer of the cervix a condition like dysentery was set up, with bloody stools and colonic ulceration, perforation and stenoses. Other untoward effects have been seen in the blood, and even after cures of various affections the blood state apparently led to cachexia.

The Germans believe they have dosage so complete as to prescribe treatment which is specific, securing the desired result with certainty. In reality, however, doses may vary with the age, as in the case of the castration dose, or with some other factor. The dose for sarcoma varies with the tumor; for while lymphosarcoma is very radiosensitive, certain osteosarcomas are extremely resistant. In regard to cancer, Kehrer would begin with a trial dose, and then 4 days later make a biopsy. The permanent dose is then determined from the result of the biopsy.

We must not be too sanguine: The Germans seem too confident of the simplicity of the problem; very penetrating rays are a new advance but are not always necessary, not always harmless and not always efficacious.

BARSONY. Serration of the Greater Curvature of the Stomach. (*Wien. klin. Wchnschr.*, 1921, No. 22.)

According to the author, serration of the greater curvature is caused by the coarse folds of the thick mucous membrane which has become inelastic. Spasm and peristalsis play no part in this. Normally there exists already an incongruence between the contractility of the musculature and the elasticity of the mucous membrane. This incongruence increases when the mucous membrane has lost its elasticity. The coarse folds which run across the greater curvature produce its serration. If the stomach is properly contracted, but also distended, strong folds are found. On the other hand, in the hypertonic or ectatic, but hardly contracted stomach, only slight fold formation is present.